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STANDARDIZATION STUDY FOR ADVANCED AIRCRAFT ARMAMENT SYSTEM PRO-ETC(U)

MAY 81 L J GRAHAM, W G SCHULZ

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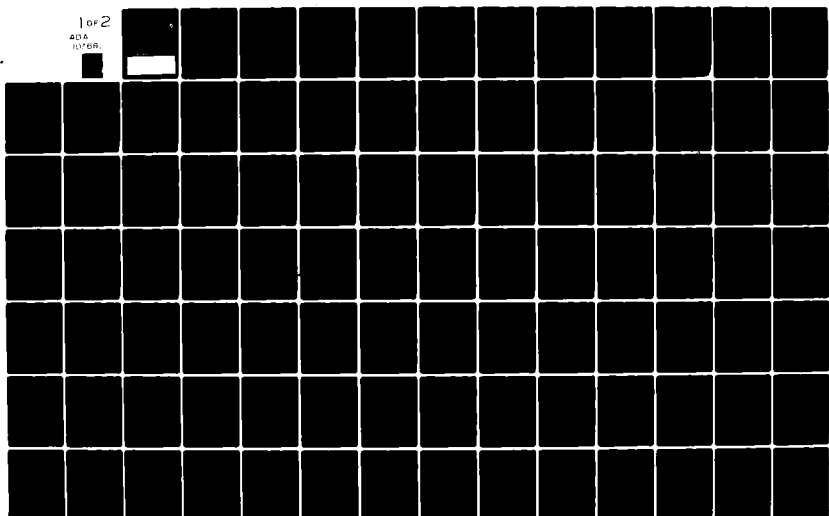
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**STANDARDIZATION STUDY
FOR ADVANCED AIRCRAFT
ARMAMENT SYSTEM PROGRAM**

May 1981

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Prepared for
AAAS TECHNICAL PROGRAM OFFICE
U.S. NAVAL WEAPONS CENTER
CHINA LAKE, CALIFORNIA 93555
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ABSTRACT

Results of a 6-month study of standardization criteria and characteristics are presented that may be effectively applied to the Advanced Aircraft Armament System (AAAS) Program. System elements feasible for standardization are identified. Standardization characteristics for those feasible elements are developed for various levels of standardization (subsystem, module, piece part) and standardization approaches (horizontal, vertical, area, functional, logistical, and cooperative). Alternative standardization characteristics are also postulated and recommendations are formulated for application to the AAAS Program.

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FOREWORD

This report was prepared by ARINC Research Corporation for the Advanced Aircraft Armament System (AAAS) Program Office (Code 31403), Naval Weapons Center, under Contract N60530-80-C-0339. Presented herein are the results of a six-month examination of standardization criteria and characteristics for various subsystems of the AAAS Advanced Development Program. The overall objective of the study was to identify and describe the standardization characteristics of candidate elements to assist the AAAS Program Manager in formulating the ADM phase of the AAAS Program.

ARINC Research wishes to acknowledge the cooperation of the Naval Weapons Center representatives who participated in the investigation. We appreciate particularly the guidance and support provided by the Program Manager, Mr. Thomas M. Leese, and the Contracting Officer's Technical Coordinator, Mr. Phil Gill.

CONTENTS

	<u>Page</u>
ABSTRACT	iii
FOREWORD	v
SECTION 1: INTRODUCTION	1-1
1.1 Scope	1-1
1.2 Background	1-1
1.3 Technical Approach	1-2
1.4 Report Organization	1-3
SECTION 2: OVERVIEW OF AAAS PROGRAM	2-1
2.1 AAAS Program Objectives and WBS Elements	2-1
2.2 SMS Subsystems	2-2
2.2.1 Control and Display Equipment	2-4
2.2.2 Process Control Equipment	2-6
2.2.3 Store Station Equipment	2-6
2.2.4 Aircraft Interface Equipment	2-7
2.2.5 Data Transfer Equipment	2-7
2.2.6 SMS Software	2-7
2.3 S&RE Subsystems	2-7
2.3.1 Primary Station	2-9
2.3.2 Missile Launchers	2-9
2.3.3 Special Stations	2-10
2.3.4 Multiple Store Adapters	2-10
2.3.5 Integration Equipment	2-10
2.3.6 Aircraft Hardpoints	2-11
SECTION 3: STANDARDIZATION CRITERIA	3-1
3.1 Impact of Standardization on AAAS Program Objectives	3-1
3.2 Standardization Criteria and Ranking	3-2
3.2.1 Technological Considerations	3-3
3.2.2 Architectural Considerations	3-4
3.2.3 Applicability Considerations	3-6
3.2.4 Economic Considerations	3-8

CONTENTS (continued)

	<u>Page</u>
3.3 Standardization Levels and Approaches	3-9
3.3.1 Standardization Levels	3-9
3.3.2 Standardization Approaches	3-10
SECTION 4: STANDARDIZATION CANDIDATES FOR EXISTING SYSTEMS	4-1
4.1 A-7 Aircraft	4-1
4.2 F-14 Aircraft	4-2
4.3 F-18 Aircraft	4-2
4.4 System Comparisons	4-3
SECTION 5: RESULTS OF STANDARDIZATION EVALUATION	5-1
5.1 SMS Subsystems	5-1
5.1.1 Control and Display Equipment	5-1
5.1.2 Process Control Equipment	5-5
5.1.3 Store Station Equipment	5-5
5.1.4 Aircraft Interface Equipment	5-5
5.1.5 Data Transfer Equipment	5-6
5.1.6 Software	5-6
5.1.7 Briefing Entry Device	5-6
5.2 S&RE Subsystems	5-7
5.2.1 Primary Station	5-7
5.2.2 Missile Launchers	5-9
5.2.3 Special Stations	5-11
5.2.4 Multiple Store Adapters	5-11
5.2.5 Aircraft Hardpoints	5-12
5.2.6 Integration Equipment	5-12
SECTION 6: AAAS ELEMENT STANDARDIZATION CHARACTERISTICS	6-1
6.1 SMS Subsystem Standardization Characteristics	6-1
6.1.1 Characteristics Recommended for All SMS Subsystems	6-1
6.1.2 SMS Subsystem Standardization Characteristics	6-5
6.2 S&RE Subsystem Standardization Characteristics	6-16
6.2.1 S&RE Subsystem Common Characteristics	6-16
6.2.2 Primary Station	6-16
6.2.3 Missile Launcher (Rail Type)	6-22

CONTENTS (continued)

	<u>Page</u>
6.2.4 Special Station	6-23
6.2.5 Multiple Stores Adapters	6-25
6.2.6 Aircraft Hardpoints	6-27
6.2.7 Integration Equipment	6-29
6.3 Implementation of AAAS Program Standardization	6-30
6.3.1 Assessment of ADM Contractors for Standardization	6-31
6.3.2 AAAS Program ADM Interface Control	6-31
6.3.3 Definition of SASI	6-32
6.3.4 Impact on Mission Aircraft	6-32
6.3.5 Development of AAAS Standardization Cost Model	6-32
SECTION 7: CONCLUSIONS AND RECOMMENDATIONS	7-1
7.1 Conclusions	7-1
7.2 Recommendations	7-2
APPENDIX A: BIBLIOGRAPHY	A-1
APPENDIX B: GLOSSARY	B-1

ILLUSTRATIONS AND TABLES

<u>Figure</u>	<u>Page</u>
2-1 AAAS Summary Product Work Breakdown Structure	2-3
2-2 Stores Management System Interfaces	2-5
2-3 Examples of S&RE Elements (from F-18 WCS)	2-8

<u>Table</u>	<u>Page</u>
3-1 Screening Categories for Technological Maturity	3-4
3-2 Categories of Architectural Suitability	3-7
3-3 Screening Categories for Multiple Usage Applicability	3-7
3-4 Screening Categories for Economic Attractiveness	3-8
4-1 Comparison of Aircraft Armament System Elements	4-4
5-1 Standardization-Ranking Criteria for SMS Subsystems	5-2
5-2 Standardization Scores and Ranking for SMS Subsystems	5-3
5-3 Standardization Levels and Feasible Approaches for SMS Subsystems	5-4
5-4 Standardization Ranking Criteria for S&RE	5-8
5-5 Standardization Scores and Ranking for S&RE	5-9
5-6 Standardization Levels and Feasible Approaches for S&RE	5-10

Section 1

INTRODUCTION

1.1 SCOPE

This report presents the results of a 6-month examination of standardization criteria and characteristics that may be effectively applied to the Advanced Development Model (ADM) of the Advanced Aircraft Armament System (AAAS) Program. The study focused on the Stores Management System (SMS) and Suspension and Release Equipment (S&RE) of the AAAS. To meet the overall objectives of the study, the following specific tasks were accomplished:

- . Identification of AAAS elements feasible for standardization
- . Development of standardization characteristics for those elements
- . Postulation of standardization alternatives for each feasible element, and formulation of recommendations for the most effective method of standardization
- . Preparation of a report documenting the above.

The study was performed by ARINC Research Corporation for the AAAS Program Office, Naval Weapons Center (NWC, Code 31403) under Contract N60530-80-C-0339. The effort drew upon several previous ARINC Research studies in developing and applying standardization criteria to Department of Defense avionics equipment, and extensive information supplied by NWC on past, current, and projected SMS, S&RE, and stores.

1.2 BACKGROUND

Very little standardization has been realized in the development of aircraft weapon control systems, including SMS and S&RE. Consequently, a proliferation of highly specialized SMS and S&RE has accrued in the Navy inventory. Many of these items perform identical functions but differ in design because of the armament system configurations they support. The result is an extensive inventory of racks, adapters, launchers, ejector units, pylons, electrical and mechanical connectors, cartridges, and electronic stores management equipment. These items provide stores carriage, communication to or control of stores, delivery programming, release, and jettison during the mission cycle.

The inventory of different types of stores is also large (more than 100) and continues to grow as a result of development and acquisition programs of DoD and member nations of the North Atlantic Treaty Organization. Stores include a wide variety of bombs, missiles, pods, fuel tanks, dispensers, and guns.

On the aircraft side of the interface, SMSs are unique to each aircraft type and sometimes each model. SMSs of older aircraft are generally hard-wired, are not integrated nor automated, and reflect obsolescent electronic designs. Although new aircraft SMS designs are based on current technologies, they are still tailored to a specific stores list and are not designed to accommodate new or different stores.

In the progression of Navy aircraft development, considerable emphasis has been given to specific technical performance but relatively little attention to armament system standardization and interoperability. This has resulted in the proliferation problem described above. Because of personnel and space limitations on Navy carriers, this proliferation has had an adverse effect on operations and maintenance.

Current aircraft mission effectiveness is degraded by lack of interoperability among the services, performance characteristics based on older technologies, and excessive logistics demands of the varied types of aircraft armament systems. The introduction of new stores or aircraft into the inventory typically requires unique aircraft armament systems or major new equipment designs or modifications. Further, there is an increasing desire on the part of DoD to increase service and Allied Nation interoperability between aircraft and stores.

The basic operating capability and flexibility in sea and air superiority that the Navy must maintain dictates arming aircraft at sea. This factor puts a premium on simplified and improved-performance armament systems, and establishes goals for standardization and interoperability. Further, advances in technology have made it possible to design and develop significantly improved S&REs and SMS compatible with fleet interoperability, multi-mission, rapid reconfiguration, and modernization goals.

In response to these needs, the AAAS Program was initiated within NWC. Further, a joint Navy/Air Force Aircraft Armament Interoperability Interface (A²I²) agreement has been reached and a program established to improve multi-service interoperability.

1.3 TECHNICAL APPROACH

The technical approach to this study was structured into four tasks, as follows:

- Task 1: Identify AAAS Elements Feasible for Standardization

Under this task, the AAAS elements considered most feasible for standardization were identified. This was done by reviewing documentation on armament systems of current Navy aircraft (A-7, F-14, and F-18) as

well as on future armament systems. A list of all AAAS SMS and S&RE subsystems considered for standardization was compiled, along with the criteria for their selection, and correlated to the AAAS Program work breakdown structure (WBS). The degree or level of standardization feasible for each element (subsystem, module, and/or piece part) and the applicable standardization approach (horizontal, vertical, area, functional, logistical, and/or cooperative) were also identified. Results of this task were presented at Technical Interchange Meeting (TIM) #1 on 21 November 1980.

- . Task 2: Develop Element Standardization Characteristics

Using the results of Task 1, characteristics of those AAAS SMS and S&RE elements deemed most attractive for standardization were developed. The characteristics took into consideration the functional, electrical, physical, and environmental aspects of the elements' interfaces. Rationale was provided for each selected characteristic based upon qualitative assessments of technology, potential cost impacts, intraservice commonalities, and interoperability requirements. Results of Task 2 were presented at TIM #2 on 20 January 1981.

- . Task 3: Develop and Recommend Standardization Alternatives

During this task, alternative characteristics for the AAAS standardization candidate elements were postulated. This task was conducted in the same manner as described above for Task 2. Results of Task 3 were presented at TIM #3 on 18 February 1981.

- . Task 4: Prepare Standardization Study Report

This report was prepared to document the technical approach, results, conclusions, and recommendations of the study.

1.4 REPORT ORGANIZATION

The study scope, objectives, background, and technical approach have been presented in this introductory section. In the remainder of the report:

- . Section 2 provides an overview of the AAAS Program.
- . Section 3 discusses standardization criteria, levels, and approaches.
- . Section 4 presents standardization candidates of existing systems.
- . Section 5 identifies the AAAS elements that can be feasibly standardized.
- . Section 6 develops standardization characteristics for SMS and S&RE elements. Supporting rationale is provided for each recommendation based upon considerations of technology, cost, and interoperability. Recommended next-actions are also presented concerning the achievement of the standardization objectives of the AAAS Program.
- . Section 7 summarizes the conclusions and recommendations of the study.
- . The appendixes provide support information (bibliography and glossary).

Section 2

OVERVIEW OF AAAS PROGRAM

This section provides an overview of the AAAS Program, with emphasis on SMS and S&RE. Knowledge of how each WBS element of SMS and S&RE functions, and determination of the degree to which standardization already exists in these areas, are prerequisites to developing further standardization criteria and recommendations.

2.1 AAAS PROGRAM OBJECTIVES AND WBS ELEMENTS

The AAAS Program, under the technical direction of NWC, will utilize a system approach to developing advanced armament system designs and joint Navy/Air Force/NATO interface specifications and standards. These specifications/standards will be applied to future development programs for aircraft and related weapon systems to ensure interoperability.

As documented in the AAAS Program Master Plan, the development program has four objectives:

- . Improved performance of aircraft armament systems
- . Greater mission flexibility to accommodate new or improved capabilities
- . Reduced requirements for armament supportability
- . Enhanced readiness through improved aircraft-to-stores interoperability

To achieve the above objectives, the AAAS Program will develop and demonstrate the design and functional feasibility of improved equipments, assemblies, and components of Navy aircraft armament subsystems. These improvements will be made in functional areas that not only require enhanced performance, but where technological advancements have made it possible to realize these improvements. The AAAS Advanced Development Model (ADM) is intended to demonstrate significantly improved supportability characteristics over existing armament equipments in the Navy. Specifically, improvements in the following supportability characteristics are expected:

- . Increased reliability through reduced complexity, fewer parts, and extension of preventive maintenance times to lessen the number of maintenance-induced failures.

- . Enhanced maintainability through reduced complexity, fewer parts, greater accessibility, simplification of overall repair and replacement philosophy, and designs that provide for reduced reconfiguration and fault isolation times.
- . Reduced logistics support through decreased requirements for servicing, training, and spares allocation; and simplification of parts repair and replacement procedures.

Finally, the joint Navy/Air Force Advanced Aircraft Interoperable Interface (A²I²) Program, as funded and supported by the AAAS and the Air Force Interface programs, will develop and validate a set of joint Navy/Air Force standards and specifications for mechanical and electrical interfaces between aircraft armament systems and stores. When implemented, these specifications/standards will produce stores interface interoperability among all future stores and future aircraft. The interoperability of existing stores with future aircraft, and of existing aircraft with future stores, will be addressed in both the AAAS and A²I² programs.

The AAAS Program has been organized into the product WBS illustrated in Figure 2-1. The scope of this study was limited to SMS and S&RE WBS elements. The SMS provides the interface between the aircrew and various aircraft stores and associated S&RE. This interface will provide the aircrew with the communication, control, and display functions necessary for efficient management of stores during various phases of a mission. The S&RE is the mechanical portion of the armament system and consists principally of bomb racks, missile launchers, dispensers, multiple stores adapters, related hardware and services, and aircraft carriage structures.

The AAAS ADM Program has been structured into three phases. Phase I, Requirements Definition and Conceptualization, will competitively establish the requirements of SMS and S&RE. Phase I is scheduled to begin in mid-1981 and continue for 6 to 8 months. Phase II, Design and Development, will provide for the fabrication and testing of the SMS and S&RE ADMs. Phase II is scheduled to begin in 1982 and will continue for 18 to 22 months.

At the conclusion of the SMS and S&RE hardware development efforts, the AAAS Program Office will conduct Phase III tests to validate the functional and operational performance of ADM hardware. This Phase III validation program will include both ground and flight testing using F-14 aircraft and a simulated F-14 cockpit and lower fuselage structure. The primary objectives of the ground test bed program are to integrate the total system, check out the operation of ADM hardware and software in all modes of operation, and conduct simulated ground and flight operations, including maintenance, reconfiguration, loading/unloading, and mission performance. The installation of the AAAS elements in the F-14 flight test aircraft will provide a means of evaluating the performance of the AAAS ADM hardware and software in the in-flight environment.

2.2 SMS SUBSYSTEMS

The SMS provides the interface between the aircrew and various aircraft stores. The SMS is the medium through which the S&RE and stores being

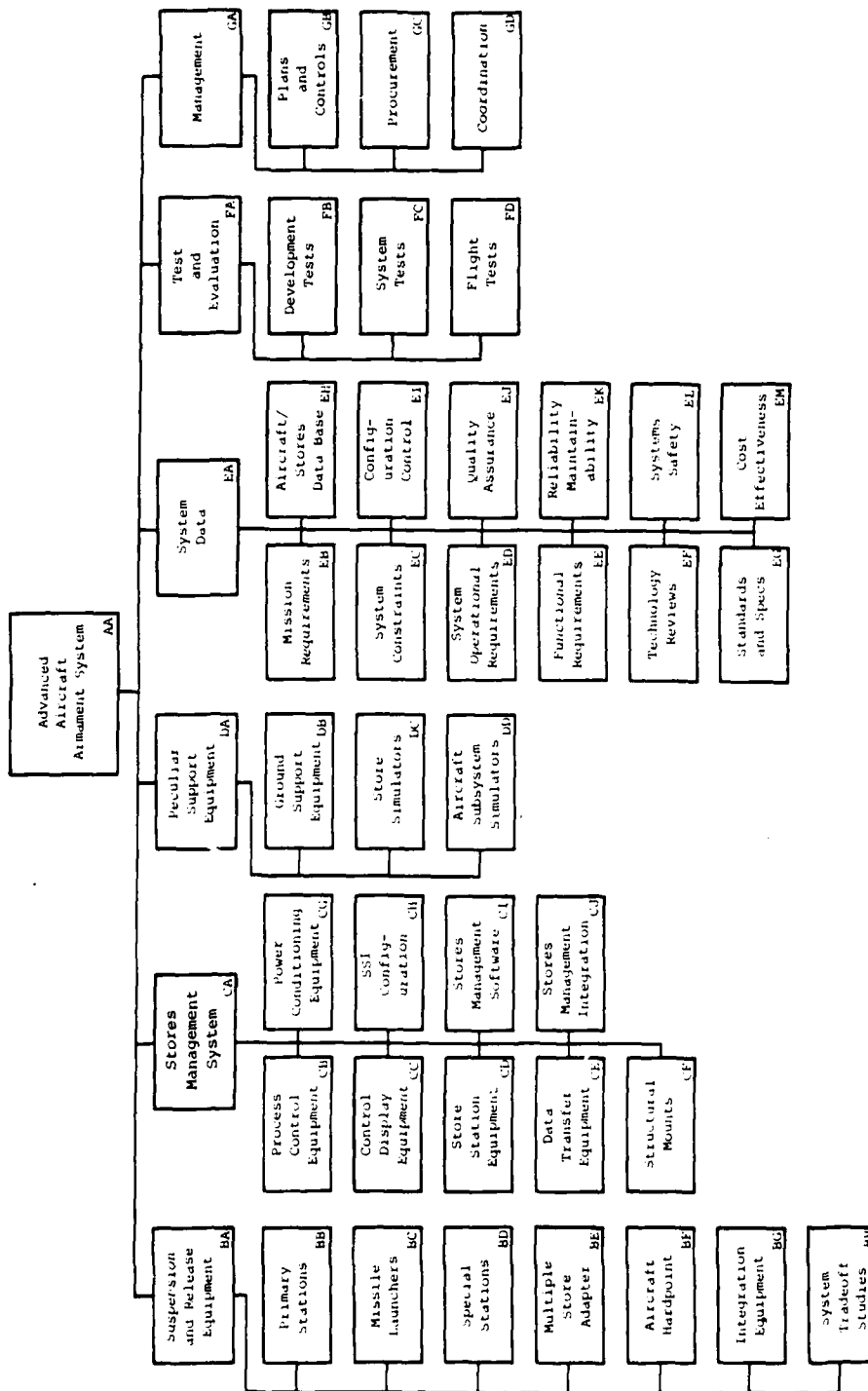


Figure 2-1. AAAS SUMMARY PRODUCT WORK BREAKDOWN STRUCTURE

carried are integrated with the balance of the avionics system, other aircraft systems, and air and ground crews. Figure 2-2 illustrates these three interfaces.

The crew-to-armament system interface provides system access for both the ground crew (maintenance and support) and aircrew. This interface is provided by the control and display equipment located at the aircrew stations and by any other indicators and controls that may be required for the ground crew interface. The second interface, that of the aircraft system to armament system, provides the physical connection via aircraft interface equipment (AIE) between various aircraft systems (e.g., inertial navigation system, environmental control system, central air data computer, etc.) and the armament system. Finally, the third interface, armament system to stores, is provided through the store station equipment. This interface is intended to support existing as well as developmental and future stores. The store station equipment will interface with the A²I² Standard Armament System Interface (SASI), consisting of the Standard Aircraft Interface (SAI) and the Standard Store Interface (SSI).

The AAAS SMS is planned to perform the following functions:

- . Conduct system and store tests
- . Monitor and control the operating conditions and status of the system and stores
- . Provide options and modes for store delivery and release
- . Provide interfaces between the crew and aircraft systems and stores
- . Perform power management

The SMS ADM contract development specification (NWC 31803-80-80) provides for the following six major configuration items based on the AAAS Product WBS:

- . Control and Display Equipment
- . Process Control Equipment
- . Store Station Equipment
- . Aircraft Interface Equipment
- . Data Transfer Equipment
- . Stores Management Software

The general physical characteristics and functions to be performed by each of these SMS subsystems are described in the following paragraphs.

2.2.1 Control and Display Equipment

The Control and Display Equipment (C/DE) provides the aircrew-to-aircraft interface and consists of displays capable of providing status indications and cues to the aircrew, selectors used to command the system, and the necessary controls and displays for managing the store load during the mission cycle. This interface is presently performed by store-peculiar

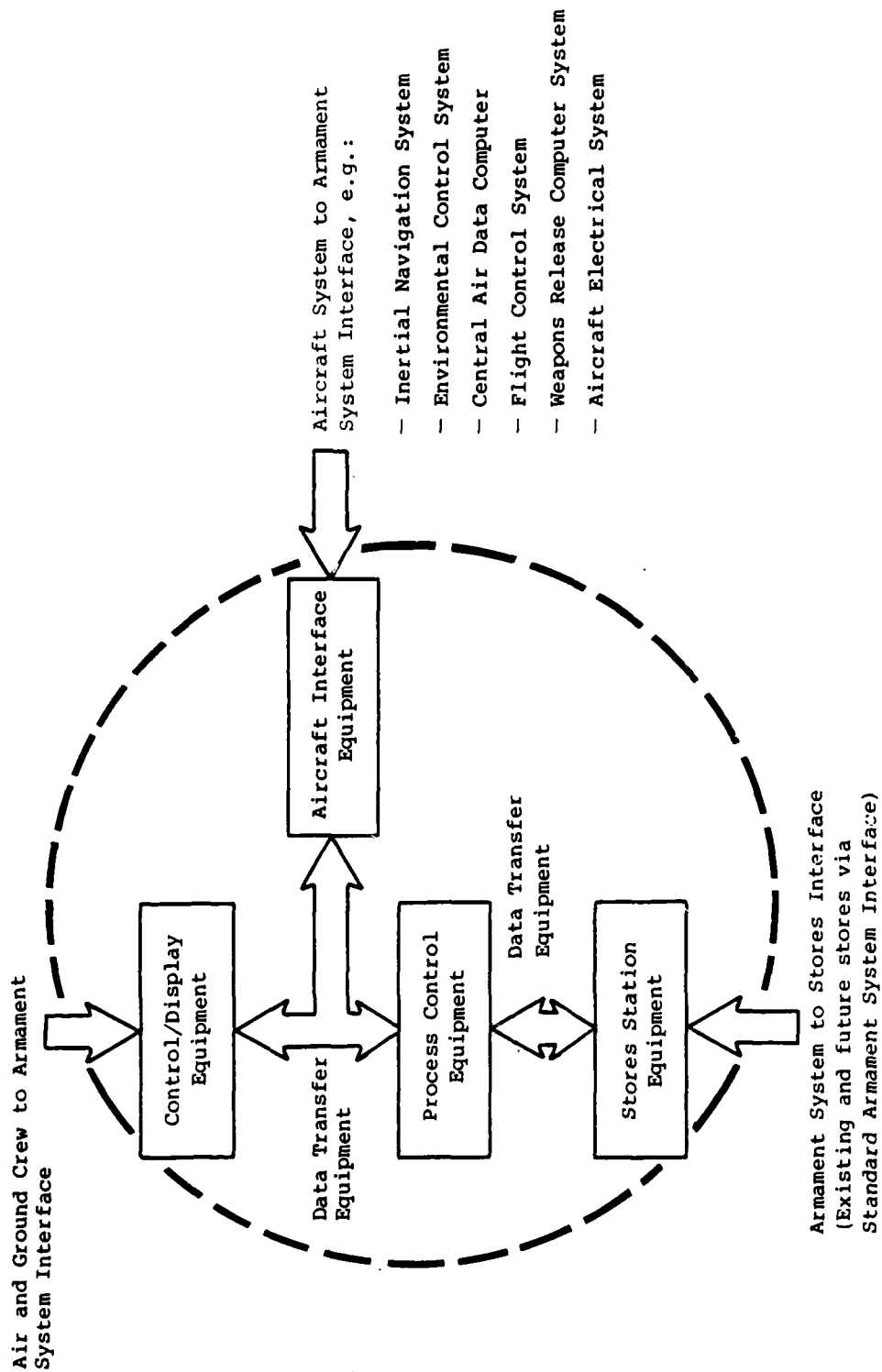


Figure 2-2. Stores Management System Interfaces

dedicated controls and displays implemented by numerous switches and lights. As a result, this interface is typically cluttered, confusing, and limited in flexibility to accommodate new stores.

The ADMs will utilize both conventional (or existing test bed aircraft cockpit) and developmental C/DE. The ADM controls are expected to be programmable, multifunctional selectors for setting modes, creating store employment or selective jettison sequences, and performing system test and checks. The ADM displays are expected to include a multifunction CRT panel, based on technology demonstrated in the F-18, that will include discrete indicators (e.g., store ready, warning, etc.). The displays will provide SMS operators with the status and operating conditions of the SMS, associated S&RE, and loaded stores.

2.2.2 Process Control Equipment

The Process Control Equipment (PCE) provides the SMS executive functions and the handshake or arbitration between other SMS elements and between the SMS and other aircraft avionics. Whether the PCE is centralized, distributed throughout the SMS, or a combination of the two will depend upon the requirements and system architecture chosen. The PCE will be a digital minicomputer with storage capability and may utilize a digital multiplex data bus (see Section 2.2.5) and resident software written in a high-order language (see Section 2.2.6). Finally, the PCE will utilize bulk memory to accommodate store application programs. The store programs would include computer routines to initialize weapons, perform BIT inquiries, conduct prelaunch functions, conduct station inquiries, set fuzes, and launch stores.

The AAAS Program will utilize an AN/AYK-14(XN-1) airborne digital computer as GFE in the ADMs of the SMS. The computer will be employed for overall executive control of the SMS and all other SMS digital processing functions not allocated to or embedded in other SMS systems (e.g., store station equipment, controls and displays, etc.).

2.2.3 Store Station Equipment

The Store Station Equipment (SSE) provides the interface between the SMS and S&RE/stores. This interface includes electrical (power and signal characteristics), logical (transmission of digital data), and physical (electrical connector) aspects. It provides switching functions, e.g., store identification, store separation sensing for inventory control, and signal conditioning for signals to and from the store. Passing through this interface from the SMS to the store are command and control functions, while passing in the opposite direction are data that reflect store status. The signals passing through the interface may include digital multiplex, high frequency analog, video, low frequency analog, ac power, and dc power.

The ADM SSE has been functionally partitioned into the following modules:

- . Data bus and wiring interface - Maintains the communications to and from the PCE.

- . Process control area - Interprets messages from the PCE and the store and causes the appropriate events to occur at the Standard Aircraft Interface (SAI) of the Standard Armament System Interface (SASI).
- . Signal conditioning area - Provides any conversions necessary to reflect the proper electrical interface for each store type.
- . Power conditioning area - Conditions and controls the power to the SSE, stores, and S&RE, as required.

2.2.4 Aircraft Interface Equipment

The Aircraft Interface Equipment (AIE) accepts information from the aircraft avionics and other aircraft subsystems and sends the information in the appropriate format to the PCE. The AIE also transfers information, as required, from the PCE to the avionics and provides the interface between the SMS and other aircraft subsystems.

In the ADM, the AIE will be implemented to support those stores to be utilized with the ground and flight test beds.

2.2.5 Data Transfer Equipment

Data Transfer Equipment (DTE) is the medium used to transfer information among the various subsystems of the SMS. Several communication modes are anticipated, with digital multiplex data busses and discrete wires used to transfer the data. Functions such as high- and low-frequency analog signals and switched dc will utilize discrete wires. Depending upon the SMS architecture chosen, the DTE may either contain the system controller or the controller may be embedded in the PCE. Finally, fiber optics will be investigated as a data transfer medium.

2.2.6 SMS Software

The Stores Management System Software includes all operational and applications computer programs required to develop and integrate the SMS subsystems. To achieve the desired flexibility, adaptability, and modularity in the ADM, the SMS software is expected to be utilized in the PCE, C/DE, and SSE.

All ADM software is to be developed using high-order language, as a baseline, and modular structuring to facilitate program changes and validation. These features are also expected to facilitate growth to accommodate future stores.

2.3 S&RE SUBSYSTEMS

Suspension and Release Equipment (Figure 2-3) make up the mechanical portion of the AAAS from the aircraft hardpoint interface to the stores interface. S&RE includes bomb racks, missile launchers, dispensers, multiple store adapters, integration equipment, and the attachment/interface items associated with the aircraft structure (hardpoints) at the weapon station. For the

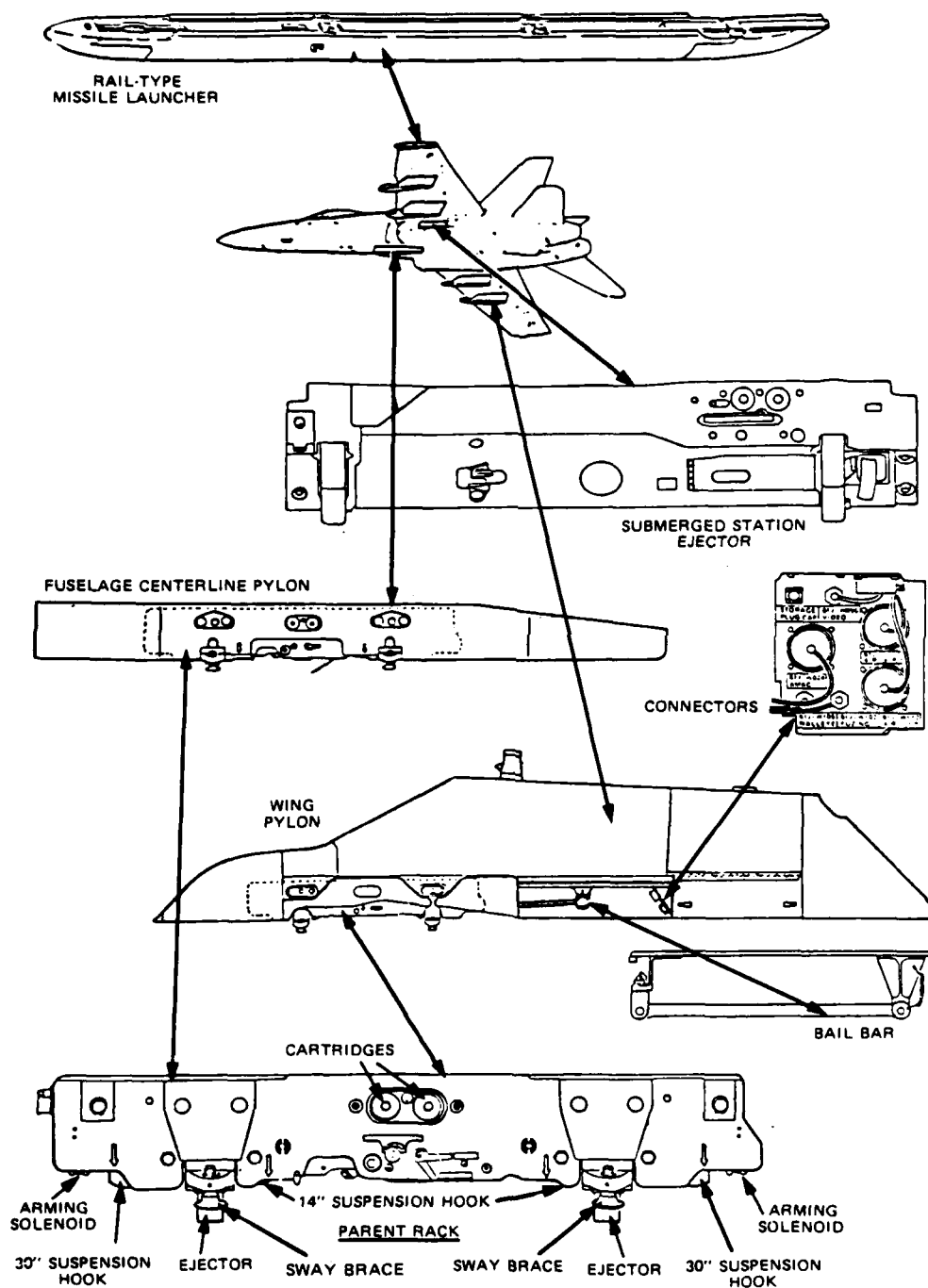


Figure 2-3. EXAMPLES OF S&RE ELEMENTS (FROM F-18 WCS)

AAAS Program, the mechanical items have been partitioned into the following categories as reflected in Figure 2-1:

- a. Primary Stations
- b. Missile Launchers
- c. Special Stations
- d. Multiple Store Adapter
- e. Integration Equipment
- f. Aircraft Hardpoint

Principal characteristics and functions of each category are described in the following sections.

2.3.1 Primary Station

The Primary Station is a versatile ejection-type store station consisting of a 30" Modular Unit Suspension Equipment (MUSE), and the Standard Armament System Interface. Functionally, the Primary Station provides for retention and separation, weapon arming and safing, store sensing, and servicing for any 30" vertical-ejection store weighing up to 5,000 pounds. Typical stores include free-fall conventional and nuclear weapons, gun and EW pods, Class B and C missiles, and fuel tanks.

The Primary Station is intended for application with a number of different carriage modes, including pylon, conformal, semisubmerged, and bomb bay. This function is presently performed by a series of "parent racks", each modified to suit the peculiar requirements of a particular aircraft/stores combination. Reduction of the number of various special suspension items and interface components is a major objective of the AAAS Program.

2.3.2 Missile Launchers

Two types of Missile Launchers, rail and eject, are used to accommodate the forward-launched guided missiles for aircraft applications. The type of launcher is dictated by the characteristics associated with the three missile classes. Class A missiles are lightweight, highly maneuverable, high-acceleration weapons characterized by the AIM-9 Sidewinder series, and are typically rail-launched. Class B missiles are medium-weight, high-acceleration devices with somewhat longer range, characterized by the AIM-7 Sparrow, and are designed for either type of launch. The missiles in the Class C category are the heaviest types with longest range, such as the AIM-54 Phoenix, and are ejector-launched.

A number of specialized launchers are presently needed to accommodate the variety of ejection-launch missiles and their parent aircraft. A goal of the ADM Program is to satisfy all Class B and C ejection-launch requirements with the 30" MUSE, utilizing its functional capabilities without special adapters.

The rail launcher functionally provides for retention, release, arming and safing, sensing, and servicing of Class A and B missiles. Presently, several specialized rail launchers are required to meet inventory needs. Accommodation of these two classes of missiles may require two rail configurations. As part of the AAAS Program, their combination in a common launcher is being considered. The rail launcher is to provide for attachment to the aircraft at fuselage and wing tip hardpoints and to the 30" MUSE (parent rack).

2.3.3 Special Stations

Several items comprise the Special Stations; gravity bomb racks (shackles); the dispensers for chaff, flares, and sonobuoys; the 14" MUSE, some 30" MUSE stations, and other elements.

The gravity racks provide for stores suspension on slower speed aircraft. As a result, they are lighter and smaller than the MUSE, which must satisfy the higher-stress tactical aircraft environment. The gravity racks provide stores retention, separation, weapon arming and safing, store sensing, and servicing similar to the MUSE. Attachment is to the aircraft hardpoints.

Dispensers retain and release the chaff and flares. They are attached in specific recesses in the aircraft fuselage.

The Special Station can utilize either the 30" or 14" MUSE (although the principal Special Station uses the 14" MUSE). When the 30" MUSE is used, the only difference between the Primary and Special Stations is the absence of one of the Primary Station SASI elements. With the 14" MUSE, the Special Station provides for attachment, restraint, ejection and fusing/arming of any 14" vertical ejection store up to a weight of 1,000 pounds (nominal). When configured with the 14" MUSE, the Special Station may have a fuel interface to accommodate the special fuel requirements of aircraft limited to the use of the 14" MUSE.

The 14" MUSE will be attached to the aircraft hardpoints in a manner compatible with the retention method and geometry used for the 30" MUSE. In addition, the 14" MUSE will be attached to the Multiple Stores Adapter strongback to serve as its store retention device.

2.3.4 Multiple Store Adapters

To increase the store-carriage capability of aircraft with limited store station hardpoints, the Multiple Store Adapter is an important element of the S&RE system. As the name implies, this device increases the stores capacity of the Primary and Special Stations using the 30" MUSE. The MSA-2 also increases the stores capacity of stations using the 14" MUSE.

The MSA-2 consists of a strongback with both 14" and 30" suspension, while the MSA-4 consists of a 30" suspended strongback assembly. The MSA-2 and MSA-4 provide attachment points for two or four 14" MUSES, respectively. They distribute the arming and release commands, sense the presence of stores, perform self-test, and provide an aerodynamically efficient and low radar cross-section shape for the attached 14" MUSE.

This function is currently provided by the Multiple Ejector Rack (MER-7) and Triple Ejector Rack (TER-7), but their aerodynamic and radar cross-section characteristics require substantial improvement.

2.3.5 Integration Equipment

The principal items in the Integration Equipment category are additional power sources and carriage mode supplementary equipment.

In the event that future stores require an alternative to pyrotechnic devices as energy sources, or utilize a powered or boosted launch, hydraulic and pneumatic power would be candidate sources. Consideration of these power forms would require use of an aircraft-developed source. However, while the pyrotechnic devices used in current systems have exhibited some undesirable characteristics in past designs, recent improvements have shown considerable promise in cleaner, more uniform performance.

Carriage modes include conformal, pylon, semisubmerged, and bomb bays. Conformal carriages offer potential for reducing the detrimental effects of external stores on aircraft performance, and reducing the aircraft radar cross-section by providing an aerodynamically "clean" covering for the stores. To accommodate the S&RE and stores within such a structure, various fairings, shrouds, or trays may be required. Use of pylons as aircraft hardpoints, while aerodynamically less desirable than conformal carriage, is necessary in some applications. The pylons may also require some special interface devices to achieve desired aircraft/stores compatibility. Semisubmerged stores carriage, while not specifically addressed in the AAAS ADM Program, is another technique in current use for improved aircraft performance and reduction of radar cross-section. Interface/integration equipment may be necessary to provide the widest latitude in aircraft stores compatibility.

Conformal carriages are used to a limited extent on current aircraft, but access to and selective replacement of stores have been difficult. Use of multiple stores adapters is also severely restricted with this mode. Pylons and rails (presently) and semisubmerged carriages (recently) have been the most prevalent carriage techniques, each tailored to specific aircraft/stores requirements.

2.3.6 Aircraft Hardpoints

Mechanical interface between the S&RE and the airframe (including pylons) occurs at the aircraft hardpoints. The mechanical interface provides for attachment, release, and fluid couplers (fuel, hydraulics and coolant), as well as electrical connectors. An important consideration in the interface design is the capability for alignment, mating, engagement, and connection of all connectors and couplers with a minimum of manual intervention. This capability enhances installation, removal, and safety. Presently, many of these connections are complex and must be performed manually, providing opportunities for injury and error. Standardization and simplification of the S&RE attachment is a primary objective of the AAAS Program.

Section 3

STANDARDIZATION CRITERIA

The initial task of this study was to identify elements of the AAAS Program feasible for standardization. This section defines standardization and discusses its potential contribution to the achievement of AAAS Program objectives. Various standardization criteria are discussed and a ranking system is provided to permit assessment of the attractiveness of standardization candidates. Finally, various standardization levels and approaches are described as they may apply to AAAS candidates feasible for standardization.

3.1 IMPACT OF STANDARDIZATION ON AAAS PROGRAM OBJECTIVES

As discussed in Section 2.1, the AAAS Program has principal objectives of improved performance of aircraft armament systems, greater mission flexibility, increased aircraft-to-stores interoperability, and reduced armament supportability requirements. Although adoption of selected standardization characteristics will favorably influence all of these objectives, the greatest impact will be on supportability and interoperability, thus contributing to enhanced readiness.

As defined in DoDD 2010.6, standardization is "the process by which member nations of NATO achieve the closest practicable cooperation among forces, the most efficient use of research, development and production resources, and agree to adopt on the broadest possible basis the use of: a) common or compatible operational, administrative, and logistic procedures; b) common or compatible technical procedures; c) common, compatible, or interchangeable supplies, components, weapons, or equipment; and d) common or compatible tactical doctrine with corresponding organizational compatibility".

Standardization will contribute to the AAAS objectives in the following ways:

- Supportability objective - Standardization can significantly contribute to supportability through improved maintainability and reliability and reduced logistics support requirements. Standardization can:
 - Enhance maintainability through the adoption of a standard, simple maintenance concept for all elements of the AAAS.

- Improve reliability through the selection of military-qualified parts and processes in the design and construction of AAAS elements.
- Reduce logistics support requirements through the use of common hardware, software, and support equipment.
- . Interoperability objective - Standardization can contribute to improved interoperability through the strict description of electrical, mechanical, and logical interfaces. Standard electrical interfaces can be realized through the use of a standard digital data multiplex bus. Mechanical interfaces can be standardized by utilizing common attachments, connectors, and couplers. Standard logical interfaces can be attained through employment of a standard protocol.
- . Readiness objectives - Standardization can also contribute to enhanced readiness in terms of four resource areas defined in OPNAVINST C-3501.66B: personnel, equipment and supplies on hand, equipment availability, and training. Specifically, standardization can:
 - Contribute to personnel readiness by reducing the quantity and skills of people needed to perform the mission, since standardized subsystems will be easier to operate and maintain.
 - Increase the chances of having needed equipment and supplies on hand by reducing the quantity of unique items required to perform the mission. Standardized items are more readily supplied, thus enhancing readiness.
 - Contribute to equipment availability through the application of standard packaging, parts, and processes that enhance the characteristics of reliability and maintainability.
 - Reduce training requirements through use of standard equipment and procedures, thus contributing to enhanced readiness.

3.2 STANDARDIZATION CRITERIA AND RANKING

Standardization studies conducted over the past few years have recognized that not all items make good standardization candidates, for technical, operational, or economic reasons. Presently there are no universally accepted, quantitative measures for determining the attractiveness of a particular subsystem for standardization. However, general guidelines for making such evaluations have been developed in recent studies by ARINC Research. In one of these studies, conducted in support of the Air Force Avionics Standardization Program, an assessment was performed of system and subsystem standardization opportunities. Four general selection criteria were developed and applied that were widely accepted by the R&D community. These criteria are briefly as follows:

- . Technological - The technology must be mature.
- . Architectural - The subsystem must perform identifiable, discrete, and separable functions.
- . Applicability - The system specification must be broadly applicable to weapon system requirements.

- . Economic - A sufficient market must exist for new systems within the period under consideration.

It is realized that these criteria are not a comprehensive set of considerations for selecting standardization candidates; however, a review of SMS and S&RE subsystems against these factors encourages a disciplined examination, providing useful insight into the issues that must be reconciled. The following sections discuss critical aspects of each of these criteria with respect to standardization, and develops the application of quantitative and qualitative measures. A few broad inferences are drawn regarding the characteristics of high-potential standardization candidates, as well as other issues that should be addressed to increase the level of standardization within the aircraft armament system community.

3.2.1 Technological Considerations

Developments in technologies applicable to SMS and S&RE have progressed rapidly in recent years. Improvements in packaging, reliability, and performance made possible by large-scale integration (LSI) and microprocessor technology have been especially significant. Fiber optics technology promises further space and weight reductions in the digital communications buses between sensors and processors for SMS subsystems. Technological advances in materials also offer potential for enhanced mechanical subsystem performance.

The rapid advances in such areas as the above makes it difficult to identify technologies that are "mature" and thus candidates for standardization. The degree of technological maturity actually required for consideration of standardization depends on the standardization concept adopted. If the approach is to designate a conventional military specification as a standard (e.g., logistical standardization approach), then a very high degree of technological stability is desirable. This situation has prevailed in voice-radio designs for many years, and a high level of standardization has been achieved by all of the military services for such equipment.

Specifications may also be limited to equipment interfaces (mechanical, electrical, environmental), thus permitting considerable flexibility for technical innovation within the equipment. The commercial airlines have employed this form of standardization for many years. The commercial standardization approach has resulted in a family of interface standards, or "ARINC Characteristics". Within the family of commercial interface standards are several advanced-technology avionics. For example, equipment being built for the Air Transport Inertial Navigation System (ARINC Characteristic 561-11) embodies precision-gimballed and strap-down inertial measurement units, digital computational circuitry, and other recently developed products. However, the system characteristic does not specify the use of any particular component - thus substitution is permitted where the manufacturer believes a better component is available. This type of system characteristic has also been called a form, fit, and function (F³) specification.

One generalization that can be made with respect to technological maturity is that it does not characterize mission-specific equipment, such as

electronic warfare systems and high resolution radar systems. The dynamics of countermeasures and counter-countermeasures have forced a short-cycle, repetitive requirement for new technological approaches to these systems. The achievement of most of the successful standardization activity in both the military and commercial aviation communities has been for the broad-based communication and navigation equipments. The definition of technological maturity, then, becomes a very elusive entity. It may be characterized as "at least one way to do it" rather than "the way to do it".

In the above-mentioned project for the Air Force Avionics Standardization Program, subsystems were categorized into three levels indicative of their technological maturity. The criteria developed for the categorization process are summarized in Table 3-1. By assigning the indicated numerical value to each of the three levels of maturity (i.e., Most Mature equals 3, etc.), a raw score may be calculated to provide a quantitative measure of the standardization attractiveness of one candidate relative to another.

Table 3-1. SCREENING CATEGORIES FOR TECHNOLOGICAL MATURITY

Category (Score)	Description	Examples
Most Mature (3)	Previous standardization precedent exists for system. Current equipment exhibits high MTBF.	AN/ARN-118 TACAN ARINC Characteristic 578-3, Airborne ILS Receiver
Moderately Mature (2)	Functionally similar equipment exists in the inventory. Improvements expected are primarily related to packaging or reliability growth.	Controls/Displays
Least Mature (1)	Performance requirements change frequently; state-of-the-art pacing equipments.	Electronic warfare systems High-resolution radars

3.2.2 Architectural Considerations

Military aircraft avionics have followed a trend toward higher levels of integration since the early 1960s. This trend was driven initially by the desire to refine and improve sensor data by combining related inputs, e.g., doppler with inertial sensors. Earlier reservations toward higher levels of integration were that the number of interfaces required to establish the architecture increased geometrically with the number of subsystems included. In addition, the loss of subsystem integrity increased fault-isolation and maintenance problems.

While fault isolation still remains a problem, the move to all-digital concepts has greatly reduced interconnectivity design penalties. In addition, the steady increase in the number of components per integrated circuit, combined with the production efficiencies permitted by LSI (and potentially VLSI) technology, have outpaced analog design concepts in the direction of economic attractiveness. The cost of digital integrated circuits has decreased since 1959 by approximately 28 percent per year. Production costs for comparable analog circuitry have also decreased, but at a rate less than half that for digital circuits. Thus the transition to all-digital avionics and a digital architectural concept is driven by powerful economic forces.

Federated multicomputers represent the state of the art in military-integrated digital avionics systems. The USAF concept, Digital Avionics Information System (DAIS), features the MIL-STD-1553A multiplex bus with centralized bus control and dual redundant central computers. The DAIS architectural philosophy is software-oriented and partitions software along processing lines (e.g., computation of angular velocity and dive angle) rather than functional lines (e.g., navigation, weapon delivery), thus reducing redundancy and the attendant high software costs associated with conventional avionic configurations. The high-speed bus permits the distribution of processing functions and enhances the "graceful" degradation qualities of the system. The DAIS Program has given impetus to a number of important military standardization decisions, including MIL-STD-1553A/B, the use of JOVIAL 73 high-order language, and control/display concepts.

Rapid advances in microprocessor and platform sensor technology produces an alternative firmware-oriented architectural concept. The distributed inertial sensor technology has been termed Multifunctional Inertial Reference Assembly (MIRA). The combination of MIRA and distributed microprocessors is also a compatible concept with the MIL-STD-1553 MUX bus protocol and provides for a low-cost growth potential in the hardware. The significant effect of the alternative architectural concept is on the design of equipments that are to be both retrofitted on older aircraft and installed as production avionics on new aircraft. If current software concepts prevail, many of the functions currently performed by individual aircraft sensors could be distributed elsewhere in the architecture. While the distributed concept may be desirable from the viewpoint of software efficiency, it makes sensor standardization difficult during the transitional phase of current inventory to the newer aircraft. It is difficult to isolate a "separate and discrete function" when the software is partitioned differently among older and newer aircraft. Therefore, for equipments with extensive software, it may be necessary to establish several sets of standards - one or more for inventory aircraft and one for aircraft in the conceptual stage. The use of alternate, firmware interface front-ends offers an approach to accommodating differences in signaling formats in the transitional period.

Yet another digital architectural concept has appeared in new transport-aircraft avionics designs for the commercial airlines. This concept features a low-speed digital data bus and four information processors - flight control, flight management, flight warning, and flight augmentation. The ARINC standard for this concept is entitled "Digital Information Transfer Standard (DITS)" and is described in ARINC Specification 429. There are primary differences, however, between the commercial and military standards discussed above.

The key distinction - and an important consideration for the development of alternative architectural concepts for the military - is that the output requirements given in the military standard are forced on a few central architectural components rather than on the subsidiary sensors.

MIL-STD-1553A describes the signal format for a very high speed multiplex (MUX) bus having equal numbers of transmitter and receivers. The Mk 33 DITS describes a ternary bus system that broadcasts labeled-digital parameters similar to the ARINC Characteristic 575 air data system. The broadcast approach is tailored to an architecture where information is distributed to multiple users from a small group of sensors. The MIL-STD-1553 MUX approach is tailored to the situation for a network of distributed control points. This latter approach reduces the number of inputs but requires more sensor outputs for the response. A fundamental commercial specification philosophy has been to minimize black box output requirements - thus the choice of the broadcast standard was strongly influenced by the airline community's desire to minimize subsystem design requirements.

The digital architectural philosophy ultimately accepted may be one lacking in design flexibility. The transition from analog to digital should therefore include any other desirable interface changes that would otherwise be deferred in the interests of evolutionary development and backward compatibility. The airlines have elected to make a sharp departure in architectures with the parallel introduction of ARINC Specification 429 and Specification 600. The latter document promotes the use of recent innovations in low-insertion-force connectors and improvements in air-cooling concepts. Similar types of interface changes are currently under consideration by the military services.

The measure of architectural suitability proposed for avionics subsystems encompasses combinations of the software and interconnectivity levels represented in equipment candidates. Table 3-2 presents the categories chosen and representative examples from the referenced Air Force Avionics Standardization Study.

3.2.3 Applicability Considerations

Existing Air Force procedures for developing retrofit avionics requirements do not lend themselves to the identification of large-lot standardization opportunities. The need for new avionics arises when the changing threat indicates a need for force improvement or when a technological opportunity has been identified for exploitation. These circumstances drive mission-specific solutions and focus attention only on that fraction of the inventory applicable to those missions.

Similarly, during the conceptual design of a military aircraft, trade-offs are performed to optimize the avionic, propulsion, and airframe components for the expected missions. Aircraft-peculiar avionics requirements may result from such a trade study that do not lend themselves to standardization concepts. For example, the cost-effective approach might be to combine a sophisticated missile avionics system with a relatively inferior airframe/propulsion design. The resulting avionics requirements may well be over-specified for general application.

Table 3-2. CATEGORIES OF ARCHITECTURAL SUITABILITY

Category and Score	Description	Examples
Most Attractive (3)	Low degree of interconnectivity with other avionics subsystems; very low internal software implementations	UHF radio HF radio
Moderately Attractive (2)	Low degree of interconnectivity with other avionics subsystems; moderate or higher degrees of software implementations within subsystem	MLS Weather radar
Least Attractive (1)	High degree of interconnectivity with other avionics subsystems; moderate or higher degrees of software implementation within subsystem	Air data system Fire control radar

To a large extent, the degree of applicability for a particular equipment across aircraft types has been determined through an evolutionary implementation process. UHF radios, for example, are installed on every military aircraft, while HF radios are generally installed only on long-range aircraft or those requiring communication on command links peculiar to that frequency band. Avionics requirements for planned aircraft usually follow the functional equipment configuration of the aircraft being replaced, with additional capabilities as permitted by the technology base. The assessment of multiple-use applicability for the candidates screened in the above referenced project are summarized in Table 3-3.

Table 3-3. SCREENING CATEGORIES FOR MULTIPLE USAGE APPLICABILITY

Category and Score	Description	Examples
Most Attractive (3)	Used across multiple mission areas, other military services, and in commercial aircraft.	Radio altimeter VOR
Moderately Attractive (2)	Used across multiple aircraft types and in other military services.	FLIR Laser designator
Least Attractive (1)	Used only in aircraft with similar performance characteristics operating in identical threat environment.	Data link (wide-band) Electronic Warfare Equipment

3.2.4 Economic Considerations

The final standardization screening criterion considered in the Air Force avionics examination was the candidates' attractiveness from a marketing standpoint. Historically, the avionics industry has been interested in developing a product for competitive purposes when the market base reaches several hundred units per year. The larger the market base, the more sincere the interest. Likewise, the delivery time is also important. Requirements to be filled many years in the future are a less credible inducement than those for the next few years. However, if a large number of requirements must be filled over a short period, then the production base is overextended. While a "smoothing" of requirements on a force-wide scale is desirable, standardization for achieving large-lot procurements alone is not necessarily the principal, valid economic motivation.

The cost-quantity discounts (frequently referred to as learning curves) for military avionics average a 93-percent slope on a log-linear cumulative progress curve for procurement awards to single developers. Larger benefits can be achieved with the price-lowering forces of competition in a sustained multiple-manufacturer market. The general trends inferred from current literature suggest that it is the acquisition and modification costs, rather than support costs, that have the greatest potential for cost reduction through standardization. This is attributable to the recent MTBF improvements brought about by solid-state avionics, the reduction in associated support costs made possible by more acceptable built-in test equipment (BITE), and the increasing emphasis on new maintenance concepts.

Table 3-4 presents the categories used in the referenced Air Force project. Demand quantities were developed from an Air Force avionics planning baseline document, and are based on liberal interpretation of requirements.

Table 3-4. SCREENING CATEGORIES FOR ECONOMIC ATTRACTIVENESS

Category and Score	Description	Examples
Most Attractive (3)	Greater than 4,000 installations required before 1990.	Radio altimeter Controls/displays
Moderately Attractive (2)	Between 2,000 to 4,000 installations required before 1990.	Flight director computers Bus controllers
Least Attractive (1)	Less than 2,000 installations required before 1990.	Omega DME

The above criteria are subsequently adapted in Section 5 for use in selecting SMS and S&RE subsystem candidates feasible for standardization.

3.3 STANDARDIZATION LEVELS AND APPROACHES

Assuming that a system or item is feasible or attractive for standardization, the next step is to determine the level at which standardization can be achieved and the approach (or activities) that will facilitate the desired level of standardization.

3.3.1 Standardization Levels

Standardization is not limited to a complete piece of equipment. Several potential levels of standardization are possible, corresponding to the partitioning of a piece of equipment. Classically, these levels have been generalized into the following:

- . System
- . Subsystem
- . Module
- . Component

The system level of standardization refers to the standardization of a complete piece of equipment. This level of standardization is not frequently applied, since a single item of equipment rarely performs all functions in an identical manner in all mission scenarios. To be an attractive candidate for system standardization, an equipment would have to be of proven design, possess little or no interconnectivity with other systems, be applicable without change to all assigned missions, and be suppliable by multiple, competing manufacturers. An example of system-level standardization is a UHF radio.

The subsystem level of standardization refers to the standardization of functional elements of a system or piece of equipment. Items of equipment at this level are typically called line replaceable units (LRUs) or weapon replaceable assemblies (WRAs). Examples of LRUs include the receiver/transmitter units, antenna units, etc., making up a radar system.

The partitioning of subsystems into modules provides for a further level of standardization. Items at this level are typically referred to as shop replaceable units (SRUs) or shop replaceable assemblies (SRAs) and are usually configured as circuit boards.

The lowest level of standardization is the component, which is a piece-part such as transistor or resistor.

Standardization is realized through the enforcement of various military and industry specifications. These standards can be applied to any one or to all standardization levels. However a program manager must consider and select, from among the available standards, those compatible with his program objectives and the level of standardization achievable.

3.3.2 Standardization Approaches

Standardization is a process involving the conception, formulation, dissemination, enforcement, and revision of standards. The collection of approaches or activities to pursue different standardization objectives can be generally placed into one of the following six categories:

- . Horizontal
- . Vertical
- . Area
- . Functional
- . Logistical
- . Cooperative

Horizontal standardization - also called general, commodity, or intersystem standardization - refers to the standardization of items (subsystems, modules or components) used between or among systems. In this category, an item is used in more than one system (e.g., utilizing an AN/AYK-14 in more than one aircraft series); may also be used by more than one military service; and often satisfies multiple missions.

Vertical standardization - also known as specific, project, product, or intrasystem standardization - refers to the standardization of a project or product from design to operation. In this category, an item is used in all configurations of a single system (e.g., the AN/AYQ-9 in all F-18s).

Area standardization is the standardization of items by geographic or mission area rather than between or within systems. In those instances where there is more than one supplier or application of a given item, the items are typically similar but not identical. Therefore, to meet area or mission needs, items are standardized within a mission or geographic area, whereas similar but not identical items are used between areas or missions. An example of area standardization is to use functionally similar items for strike and surveillance aircraft, but identical (standardized) items in a specific mission area (e.g., strike aircraft).

Functional standardization - also known as form, fit and function (F³) standardization - is primarily concerned with the standardization of electrical, mechanical, logical, and environmental interfaces. Items built to F³ standards may differ significantly internally, but always possess an identical size, shape, and set of functions. Functional standardization provides for interchangeability while permitting considerable flexibility for technical innovation within the item. The commercial airlines have employed this form of standardization for many years in the specification of avionics. This form of standardization is also used to establish joint service standards (e.g., MIL-STD-1760) and NATO standards (e.g., STANAG 3837AA).

Logistical standardization is the specification of every aspect of an item, including the detailing of its parts, processes, and configuration. Examples of logistical standardization are military-qualified electronic

components managed by the Defense Electronics Supply Center. Each item logistically standardized is identical in every respect to each other.

Cooperative standardization is the achievement of design standards (e.g., threads, fitting sizes, etc.) among all users, both industry and DoD.

Several of the above standardization approaches or activities can be applied in a single development program and serve to complement one another. Vertical, area, and cooperative standardization are often included collectively in a development program. An example is a standard Navy radio, with one configuration for land use and another for airborne use, designed to both industrial and DoD standards.

Associated standardization categories are:

<u>Item</u>	<u>Standardization Category</u>
Standard Navy radio	Vertical
Airborne configuration	Area
Industrial standard	Cooperative (power levels)
DoD standard	Cooperative (number of channels)

If this same radio is also used in other military services or NATO, then horizontal standardization activities could be applied. Finally, if essentially every aspect of the radio's design (i.e., parts, processes, and configuration) are identical, then logistical standardization activities are indicated. Of all of the above standardization approaches only functional and logistical standardization are mutually exclusive. However, functional standardization may be combined with other standardization approaches at the item interface level.

Section 4

STANDARDIZATION CANDIDATES FOR EXISTING SYSTEMS

As a part of the Task 1 investigation, three current aircraft armament systems were reviewed. The purpose of this review was to identify any common elements among existing systems for consideration as candidates for standardization. The aircraft designated for this review by the program sponsor were the A-7, as an example of an obsolescent technology; the F-14, as an example of a current aircraft system; and the F-18, a new aircraft scheduled for production starting in 1982.

4.1 A-7 AIRCRAFT

The A-7 aircraft represents the basic technology of the early 1960s, although system modernizing changes have been introduced. The first flight occurred in September 1965 and initial deployment was in January 1966. This single-engine, single-place aircraft is designed for a highly versatile, land- or carrier-based light attack role. It can carry a wide range of external stores, and has an internal gun.

The A-7 has three stores stations on each wing and a missile station on each side of the fuselage, for a total of eight stations. Pylons are used at each station, with pylon pairs symmetrically interchangeable about the longitudinal axis of the aircraft. Each wing station pylon contains a parent rack from the family of MAU-9 and BRU-10, and is capable of utilizing the Multiple Ejector Rack (MER-7) and Triple Ejector Rack (TER-7). Missile rails are attached to the fuselage pylons.

The Stores Management System consists of the following subsystems: weapon release, tactical computer, electrical fuzing, mechanical arming, missile control, internal gun, chaff/flare dispenser, and jettison.

Communication between systems and their elements utilizes dedicated, hard-wired aircraft cabling. Stores control is accomplished through dedicated logic, and the display is principally provided through advisory lights and annunciator panels associated with control switches.

The A-7 has a broad range of stores carriage capabilities that include air-to-air missiles such as the AIM-9 Sidewinder, air-to-ground weapons such as the AIM-45 Shrike, and the Walleye guided bomb. In addition, it is

capable of carrying a wide mix of conventional bombs, including GP, practice, destructor, retarded, cluster, and fire types. Its carriage capabilities also include mines, flares, rocket launchers, auxiliary and air refueling tanks, and nuclear weapons.

4.2 F-14 AIRCRAFT

Representative of the technology of the late 1960s, the F-14 made its first flight in December 1970. Following the loss of the first prototype later that month, the second prototype flew in May 1971, with initial production delivery in May 1972. The twin-engine, two-seat (tandem), variable geometry aircraft functions as a carrier-based, fleet-defense air superiority fighter. Although NAVAIR 01-F14AAA-75 identifies a variety of stores for use with the F-14, only air-to-air missiles and an internal gun are presently authorized armament. The F-14 has a variable sweep wing, and to simplify external stores carriage the store stations are all located on the fuselage, engine nacelles, and wing gloves. The F-14 has a variety of position-peculiar pylons and adapters to accommodate its stores. Reconfiguring the aircraft to change missile types, as would be required for a change in mission, can require a significant amount of time due to the complexity and uniqueness of the attachment components, most of which are peculiar to the F-14.

The F-14 utilizes several interactive systems for stores control. The AWG-9 and AWG-15 form the basic weapon control system. Designed by Hughes, the AWG-9 and AIM-54 constitute the primary weapon system for the F-14, with the ability to search, track and attack multiple air-to-air targets. The AWG-9 also provides fire control signals for the AIM-7 and AIM-9. The AWG-15 manages the aircraft weapons, with inputs from the AWG-9 and other aircraft avionics, providing the aircrew with various display and control options. Digital data are utilized for communications between some AWG-9 and AWG-15 system elements.

4.3 F-18 AIRCRAFT

Utilizing the technology of the late 1970s, the F-18 represents the most modern of U.S. tactical aircraft. It is designated for a dual role as replacement for the Navy's F-4 and A-7 aircraft. Powered by twin engines, this versatile, single-seat, land- or carrier-based aircraft had its first flight in November 1978. Currently undergoing extensive testing at NATC/Patuxent River, the F-18 is scheduled for production deliveries in early 1983. In its dual role, it has the ability to accommodate a wide variety of external stores.

This mid-wing aircraft has nine external store stations, including two missile-dedicated wingtip stations. The pylons for the four under-wing stations are interchangeable and utilize BRU-32 parent racks. Two semisubmerged nacelle stations with ejection launchers, and a fuselage centerline station with a special pylon and BRU-32 rack, are also provided. The wing stations can accommodate the BRU-33 vertical ejection rack (VER-2) for multiple stores.

Although the stores management system on the F-18 is composed of elements functionally similar to those of the A-7 and F-14, the system is highly flexible in allowing the pilot a broad range of options in stores control. It consists of a weapon release and rocket firing system, stores management processor and mission computers, electrical fuzing system, mechanical fuzing/arousing system, missile fire control systems (including guided glide bomb control), AMAC, internal gun system, external fuel system, chaff/flare dispenser, and jettison systems.

The stores management processor communicates with the fire control system, control and display system, and mission computers on a McDonnell Aircraft Company version of MIL-STD-1553A data bus. Avionics and controls signals are hard-wired. Communications between the stores management processor and the store station decoders are via a non-1553 digital armament mux bus.

The wing tip stations are dedicated to the AIM-9 Sidewinder, and the two outboard underwing stations can carry air-to-surface weapons. The two inboard wing stations can carry fuel tanks as well as air-to-surface weapons. The two semisubmerged nacelle stations can carry the AIM-7 Sparrow, a FLIR pod, or a laser tracker pod. The fuselage centerline station can accommodate a fuel tank as well as various bombs and the Walleye data link pod.

4.4 SYSTEM COMPARISONS

Although the A-7, F-14, and F-18 aircraft stores management systems described in the preceding paragraphs differ considerably in technology, they are functionally similar. Each comprises a stores control and release system, a computer to optimize stores control, a capability for electrically and mechanically arming or safing the weapons, individual control systems for the missile carried, a nuclear weapon control system, gun control, external fuel system control, chaff/flare dispenser system, and a jettison system. In addition, each utilizes various pylons, adapters, racks, launchers, and hardpoints.

Table 4-1 provides a tabular comparison of these elements. From this comparison it is evident that some elements are already standardized or sufficiently similar that standardization should be seriously considered at some level (subsystem/module, or part). These candidates are categorized according to the AAAS ADM work breakdown structure and assessed in greater detail in subsequent sections to evaluate their feasibility for consideration in the AAAS ADM Program.

Table 4-1. COMPARISON OF AIRCRAFT ARMAMENT SYSTEM ELEMENTS

A-7	F-14	F-18
Weapon release system circuits and controls for stores management	Bomb release and rocket fire control system circuits and controls for stores management	Bomb release system, rocket firing system
Tactical computer for weapon release	AWG-9/AWG-15 Weapon Control System	Stores management processor and computers
	AWW-4 Electric Fuzing System	
Mechanical arming system	Mechanical fuzing system	Mechanical fuzing system
	AIM-9 Fire (Missile) Control System	
AGM-45 Missile Control System	AIM-7/54 Fire Control System	AIM-7 Fire Control System
Walleye control system (AWW-7 Data Link)	(No air-to-surface weapon delivery options certified for use by this aircraft.)	AGM-65 FCS, AGM-88 FCS
AMAC (Nuclear Weapon Control)		Walleye control system (AWW-7 Data Link)
	Internal gun system	AMAC (Nuclear Weapon Control)
	External fuel system	
	Chaff/flare dispenser system	
	Jettison System	
	Pylons	
Bomb racks (14" and 30")		Bomb racks (14" and 30")
	Missile launchers (rail and eject)	
Multiple store racks (MER and TER)		Multiple store racks (VER)
	Adapters	
	Hardpoints	

Section 5

RESULTS OF STANDARDIZATION EVALUATION

In this section, criteria are developed and applied to each SMS and S&RE subsystem for evaluating its candidacy for standardization. The candidates are rank-ordered in this regard, and for each the best of the various approaches to standardization is recommended.

5.1 SMS SUBSYSTEMS

Based on the generalized guidelines in Section 3.2 and the survey discussion of Section 4, criteria for guiding the evaluation of the standardization attractiveness of SMS subsystems were developed and are presented in Table 5-1. These criteria were then applied to the six SMS subsystems identified in Section 2.2. A seventh SMS subsystem, Briefing Entry Device, although not currently identified as an ADM configuration item, has been added as a standardization candidate for consideration in the AAAS Program. The summarized results of applying the criteria and rationale are presented in Table 5-2, together with each candidate's raw score and ranking. Finally, the achievability of the level of standardization and the standardization approach most appropriate for each SMS subsystem was developed, with the results given in Table 5-3. The following sections discuss the analysis for each SMS subsystem.

5.1.1 Control and Display Equipment

Control and Display Equipment are judged moderately attractive for standardization from the technological and economic viewpoints. The rationale for this judgement is that, although functionally similar equipments exist in the inventory, improvements are expected. Further, while there is some opportunity for competition among suppliers, most C/DE types represent one-time rather than long-term periodic purchases.

C/DE are rated least attractive for standardization based upon architectural and applicability criteria. C/DE have a high degree of interconnectivity with other avionic subsystems, and are being designed with an increasing degree of software. Controls are often peculiar to certain aircraft, depending upon the aircraft stores.

Table 5-1. STANDARDIZATION-RANKING CRITERIA FOR SMS SUBSYSTEMS

Criteria	Category		
	Least Attractive (1)	Moderately Attractive (2)	Most Attractive (3)
Technological	Performance requirements change frequently; state-of-the-art pacing equipments.	Functionally similar equipments exist in the inventory. Improvements (primarily packaging, reliability, etc.) are expected.	Previous standardization precedent exists. Equipment currently exhibits high MTBF using proven technology and mature designs.
Architectural	High degree of interconnectivity with other avionics subsystems; moderate or higher degree of software implementation within subsystem.	Low degree of interconnectivity with other subsystems; moderate or higher degree of software implementation within subsystem.	Low degree of interconnectivity with other subsystems; very low software implementation.
Applicability	Used only in aircraft with similar performance characteristics or that operate in identical threat environments.	Used across multiple-aircraft types and in other military services.	Multiple mission and multiple aircraft or commercial usage.
Economic	Few suppliers and low annual demand rate - limited opportunity for competition.	Some suppliers and medium annual demand rate - some opportunity for competition.	Many suppliers and high annual demand rate - unlimited opportunity competition.

Table 5-2. STANDARDIZATION SCORES AND RANKING FOR SMS SUBSYSTEMS

SMS Subsystem	Standardization Criteria Application and Ranking					
	Technological	Architectural	Applicability	Economic	Raw Score	Rank
Control and Display Equip.	2	1	1	2	6	7th
Process Control Equip.	3	2	2	3	10	3rd
Store Station Equip.	2	2	1	2	7	6th
Aircraft Interface Equip.	2	1	2	2	7	5th
Data Transfer Equip.	3	3	3	3	12	1st
Software	3	3	2	3	11	2nd
Briefing Entry Device	3	2	2	3	10	4th
Note: 3 = Most Attractive, 2 = Moderately Attractive, 1 = Least Attractive						

Based on the ranking values given in Table 5-2, the C/DE accumulated a raw score of 6 out of a total possible 12 points (6/12). This being the lowest raw score, the C/DE are considered the least attractive of all AAAS subsystems for standardization.

As reflected in Table 5-3, standardization of C/DE is considered feasible at the subsystem level, difficult at the module level, and unachievable at the component level. Finally, of the four standardization approaches considered feasible for C/DE (vertical, area, functional, and cooperative), the functional method offers the greatest advantages to the AAAS Program. This approach will permit standardization of electrical, mechanical, and environmental interfaces of C/DE at the subsystem and possibly the module level while permitting the incorporation of new technologies, thus potentially broadening their application to multimission aircraft.

Table 5-3. STANDARDIZATION LEVELS AND FEASIBLE APPROACHES FOR SMS SUBSYSTEMS

SMS Subsystem	Levels of Standardization			Standardization Approach (See Section 3.3.2)					
	Comp. (Part)	Module (SRA/SRU)	Subsystem (WRA/LRU)	Hor.	Vert.	Area	Funct.	Log.	Coop.
Control and Display Equip.	N/A	Difficult	Feasible		X	X	X		X
Process Control Equip.	Feasible	Feasible	Feasible	X	X	X		X	X
Store Station Equip.	N/A	Difficult	Feasible		X	X	X		X
Aircraft Interface Equip.	N/A	Difficult	Feasible		X	X	X		X
Data Transfer Equip.	Feasible	Feasible	Feasible	X	X	X		X	X
Software	Difficult	Feasible	Feasible	X	X	X		X	X
Briefing Entry Device	Difficult	Feasible	Feasible	X	X	X		X	X

5.1.2 Process Control Equipment

Process Control Equipment are rated most attractive for standardization on the basis of technological and economic criteria (see Tables 5-1 and 5-2). PCE score well in these areas since there is precedent for their standardization (AN/AYK-14, AN/AWG-9, etc.), and such equipment utilizes proven technology and mature designs. Further, the many potential suppliers of PCE offer an excellent opportunity for competition.

PCE are considered moderately attractive for standardization based upon architectural and applicability criteria. The reasons are that PCE interfaces with other subsystems (although this interface is increasingly being simplified through the use of standard digital multiplex busses), and typically differ in capability and missions supported.

The PCE reflect a total raw score of 10/12 (see Table 5-2) and ranks third overall as an AAAS subsystem candidate for standardization. It can be seen in Table 5-3 that PCE are considered feasible for standardization at all assembly levels and to all standardization approaches. However, functional standardization is not recommended since the logistical approach is achievable and has been demonstrated to the component level.

5.1.3 Store Station Equipment

Store Station Equipment are considered moderately attractive as standardization candidates per the technological, architectural, and economic criteria. Functionally similar equipments exist (e.g., F-18 encoders/decoders), but improvements are expected. Further, SSE possess a low degree of interconnectivity with other subsystems (i.e., multiplex bus with PCE and SASI), and there is some opportunity for competition. Finally, SSE are considered least attractive candidates for standardization in the applicability category. This judgement was based upon the fact that SSE, to remain relatively simple, would have to be designed to accommodate a pre-defined set of multiplex and discrete signals for store control and release.

From these assessments, SSE was assigned a raw score of 7/12, thus ranking as one of the least attractive candidates for standardization. As with the C/DE, the SSE (see Table 5-3) are best standardized by a functional (F³) approach, with standardization at or below the module level considered either difficult or impossible.

5.1.4 Aircraft Interface Equipment

Aircraft Interface Equipment are judged moderately attractive for standardization on the basis of technological, applicability, and economic criteria. The rationale for this assessment was that functionally similar equipments exist (e.g., a functional module interface for the Global Positioning System receiver), the AIE will be potentially used across Navy multiple-aircraft types to accommodate new-generation SMSs, and some opportunity is apparent for competition from suppliers.

AIE are considered least attractive for standardization based upon the architecture criterion. These equipments will have a high degree of

interconnectivity with other avionics and are expected to incorporate some software-controlled functions. Further, each AIE will have to be designed to accommodate a different suite of existing avionics subsystems and store signals, depending upon the aircraft type utilizing the SMS.

Overall, AIE achieved a raw score of 7/12, making this group one of the least attractive of all AAAS subsystems for standardization. As with C/DE and SSE, AIE are best standardized by a functional approach at the subsystem level. Standardization to this approach at or below the module level would be difficult and is not recommended.

5.1.5 Data Transfer Equipment

Data Transfer Equipment are considered most attractive for standardization based upon all criteria. DTE have standardization precedents (e.g., the MIL-STD-1553 multiplex data bus), highly standardized means for interconnectivity with other systems, and multiple mission/aircraft applications. Many companies supply DTE components, thus sustaining an unlimited opportunity for competition.

As a result of the above analysis, DTE were given the highest raw score of all SMS subsystems (12/12) and hence are regarded as the most attractive for standardization. All standardization approaches except functional are recommended, and standardization is achievable at all levels.

5.1.6 Software

The Software subsystem is considered most attractive for standardization in all categories except applicability. Previous standardization precedent exists (e.g., standard HOL and MIL-STD-1679) and SW interfaces can be strictly defined through interface design specifications. Further, there are several potential suppliers of the SW subsystem, thus providing an unlimited opportunity for competition.

The SW subsystem was judged moderately attractive based on the applicability criterion, since only portions of the SMS subsystem (e.g., executive programs) may be used across multiple-aircraft types and potentially in other military services. It is expected that selected modules of SMS subsystems (e.g., application programs) will be needed to accommodate different aircraft configurations and store suites.

The SW subsystem accumulated a raw score of 11/12 and was judged the second most attractive of the SMS subsystems candidates for standardization. Standardization to the module level is considered feasible.

5.1.7 Briefing Entry Device

The Briefing Entry Device was judged most attractive based upon the technological and economic criteria, and moderately attractive for the architectural and applicability criteria. From a technological viewpoint, standardization precedent exists (e.g., Data Transfer System) and equipment making up the Briefing Entry Device incorporate proven technology and mature designs.

Further, there are many current suppliers of such subsystems, thus offering an unlimited opportunity for competition.

The moderately attractive ratings in the architectural and applicability areas were assigned, respectively, because the device 1) has a degree of interconnectivity with other subsystems, and 2) may not be adaptable across multiple aircraft types in a single configuration.

By applying the above criteria, the Briefing Entry Device attained a raw score of 10/12, suggesting that it is a favorable candidate for standardization. All standardization approaches except functional are recommended. Standardization to the module level is considered feasible, while complete component standardization may be difficult due to a requirement to adapt to different aircraft types and missions.

5.2 S&RE SUBSYSTEMS

S&RE subsystems were evaluated as to their standardization attractiveness in the same manner as for SMS. Table 5-4 provides the ranking criteria, Table 5-5 gives raw scores and relative ranking from the analysis, and Table 5-6 lists the most appropriate standardization level and approach for each subsystem. The basis for the results is discussed in the following sections for individual S&RE subsystems.

5.2.1 Primary Station

The Primary Station ranks as a most attractive candidate for standardization for three of the four evaluation categories. From an architectural standpoint, there is limited direct interface with systems other than S&RE items, and the new design will be less complex than existing equipment. The Primary Station is applicable to a number of aircraft types over a wide range of missions, and could be used for multiservice applications. From an economic viewpoint, there are a number of suppliers, and based on the Primary Station's wide application to various aircraft types and missions, an attractive market will prevail.

The Primary Station is moderately attractive for standardization based on technological maturity criteria. Equipment in the inventory is functionally similar (e.g., BRU-10 variations and associated stores interface elements), but improvements in these designs are expected.

From these assessments, a raw score of 11/12 was accumulated by the Primary Station, which makes it one of the most attractive S&RE candidates for standardization.

Table 5-6 shows the Primary Station to be feasible for horizontal, vertical, functional and cooperative standardization at both the subsystem and module levels, with functional standardization at the module level considered the most desirable. This standardization approach would permit application to multi-aircraft and cooperative approaches as well. It would also yield a

Table 5-4. STANDARDIZATION RANKING CRITERIA FOR S&RE

Criteria	Category		
	Least Attractive (1)	Moderately Attractive (2)	Most Attractive (3)
Technological	Performance requirements change frequently; state-of-art pacing equipments.	Functionally similar equipment exist in the inventory. Improvements (primarily packaging, reliability, etc.) are expected.	Previous standardization precedent exists. Equipment currently exhibits high MTBF using proven technology and mature designs.
Architectural	High degree of interface with other subsystems; highly complex subsystem design.	Moderate degree of interface with other subsystems; moderately complex subsystem design.	Low degree of interface with other subsystems; less complex subsystem design.
Applicability	Used only in aircraft with similar performance characteristics or that operate in identical mission environment.	Used across multiple aircraft types and in other military services in similar mission environments.	Multiple mission, multiple aircraft types, and multiservice or commercial usage.
Economic	Few suppliers and low annual demand rate - limited opportunity for competition.	Some suppliers and medium annual demand rate - some opportunity for competition.	Many suppliers and high annual demand rate - unlimited opportunity for competition.)

Table 5-5. STANDARDIZATION SCORES AND RANKING FOR S&RE

S&RE Subsystem	Standardization Criteria Application and Ranking					
	Technological	Architectural	Applicability	Economic	Raw Score	Rank
Primary Station	2	3	3	3	11	2nd
Missile Launchers	2	2	3	3	10	4th
Special Stations	2	3	3	3	11	3rd
Multiple Store Adapter	2	2	2	2	8	5th
Aircraft Hardpoints	3	3	3	3	12	1st
Integration Equipment	1	1	2	3	7	6th
Note: 3 = Most Attractive, 2 = Moderately Attractive, 1 = Least Attractive						

more flexible interface with aircraft and stores, providing the opportunity for incorporating the benefits of technological growth. The flexibility would also extend to the use of standard modules in other S&RE subsystems.

5.2.2 Missile Launchers

To accommodate missiles, two aircraft launch techniques are utilized: rail and ejection. The ADM program will investigate standard 30" MUSE (part of the Primary Station) as the ejection launcher for Class B and C missiles. Therefore the only launcher considered in this section is the rail-type, used for carriage and controlled separation of Class A and B missiles.

The rail-type missile launcher is considered moderately attractive for standardization from the technological and architectural standpoints. While rail launchers are widely used, they are usually of specific designs restricted to individual missile classes. The ADM program is committed to developing a common rail launcher for both Class A and B missiles. From the architectural viewpoint, some missiles will require interface with aircraft fire control systems or other avionics as part of pre- or post-launch operation, and may require boost during launch.

Table 5-6. STANDARDIZATION LEVELS AND FEASIBLE APPROACHES FOR S&RE

S&RE Subsystem	Std. Lev.*	Standardization Approach**					
		Hor.	Vert.	Area	Funct.	Log.	Coop.
Primary Station	P	D	D	D	N	D	D
	M	F	F	D	F	N	F
	S	F	F	D	F	N	F
Missile Launchers Rail	P	D	D	D	N	D	D
	M	F	F	D	F	N	F
	S	F	F	D	F	N	F
Special Stations	P	D	D	D	N	D	D
	M	F	F	D	F	N	F
	S	F	F	D	F	N	F
Multiple Store Adapters	P	D	D	D	N	D	D
	M	F	F	D	F	N	F
	S	F	F	D	F	N	F
Aircraft Hardpoints	P	F	F	D	N	F	F
	M	F	F	D	F	N	F
	S	N	D	D	N	N	N
Integration Equipment Connectors, Couplings, Cables, Hoses	P	F	F	D	N	F	F
	M	F	F	D	F	F	D
	S	N	F	D	N	N	N
Carriage	P	D	F	D	N	D	D
	M	F	F	F	F	F	F
	S	N	F	F	N	N	N
Power Sources	P	D	D	D	N	F	D
	M	F	F	D	F	F	F
	S	N	F	N	N	N	N
*Level of Standardization: P = Part, M = Module, S = Subsystem							
**Standardization Approach: F = Feasible, D = Difficult, N = Not Applicable							

The rail-type launcher was rated a most attractive candidate in the applicability and economic categories. Applicability for multiple use is a factor strongly favoring standardization, particularly if the ADM objective is attained, since all rail-launched missiles could be accommodated. From an economic viewpoint potential suppliers are numerous and the reconfiguring of the fleet as well as other service applicability would represent a significant market.

Combining these rankings, the rail launcher raw score was 10, placing it fourth in rank for standardization among the six S&RE subsystems.

The rail launcher can feasibly utilize the horizontal, vertical, functional, and cooperative approaches to standardization at the subsystem or module level (see Table 5-6). It is expected that the rail will be standardized using the functional approach at the subsystem level. This permits the use of a basic structure with rails to accommodate the current missile inventory, future missile designs, and any improvements in rail technology. Interface between the standard rail and each aircraft hardpoint may be handled by an adapter or pylon to accommodate the location-peculiar surface contours and structure variables, without imposing unnecessary weight or aerodynamic drag penalties on the rail or aircraft. Adapters or pylons, however, are an undesirable addition to the inventory.

5.2.3 Special Stations

Several subsystems are included in this category, as described in 2.3.3. The AN/ALE-29/39 has already been standardized within the Navy. A simple shackle-type bomb rack is also included in this category, but is being evaluated only for limited application in low-speed aircraft. For purposes of this assessment, therefore, those two subsystems are not being considered. Of primary interest is the group of items that include the 14" or the 30" MUSE, and the pertinent special station SASI elements.

The subsystem including these new items is very similar in function and general form to the Primary Station, as described in Section 2.3.3. In addition, most of the modular components are identical. The main difference is that the Special Station includes a 14" MUSE as well as the 30" MUSE, although they will share interchangeable modules. Based on these characteristics, the Special Station standardization criteria were rated the same as the Primary Station in all categories (see Table 5-5). Their similarity in characteristics also places them in the same category as the Primary Station in standardization approach (functional) and level (modular).

5.2.4 Multiple Store Adapters

Two adapters are included in this category - dual and quadruple (MSA-2 and MSA-4). Because of their functional similarity and commonality of modular elements, they are treated identically in this evaluation.

MSAs are considered moderately attractive candidates for standardization in all categories. From the standpoint of technical maturity, functionally similar equipment is in the inventory (MER-7, TER-7, VER-2, and the developmental MSER). The MSA is expected to provide significant improvements over

those items. Based on architectural considerations, some complexity in distributing signals and fluids, and in controlling, servicing, and sensing stores, makes the adapters moderately complex subsystems. MSAs have applicability to varied missions and aircraft, but not as extensively as the Primary or Special Stations, particularly where aircraft use conformal carriage techniques. For the same reason, the MSAs are considered to represent a moderate opportunity from an economic standpoint. Fewer suppliers are in the marketplace and the requirements should place a somewhat smaller demand on the marketplace.

The above rankings result in a raw score for MSA of 8/12 and a ranking of fifth in the S&RE category, as shown in Table 5-5.

The horizontal, vertical, functional, and cooperative approaches to standardization are feasible for the MSA. Some modular elements are to be shared with the Primary and Special Stations, dictating functional standardization at the modular level.

5.2.5 Aircraft Hardpoints

The aircraft hardpoints include the interface items between the airframe and the S&RE or airframe and pylon. In addition, physical attachment, restraint and release/jettison elements, and fuel, hydraulic, and coolant couplers form the mechanical part of the subsystem, as previously identified in Section 2.3.6.

Aircraft hardpoints are considered most attractive standardization candidates in all four categories. In terms of technological maturity, retention devices, connectors, and couplers are undergoing continued improvement but are relatively stable, mature designs and most have military specifications or standards that identify their parameters. From an architectural standpoint, they have specific, limited interface requirements. Most elements of the subsystem have broad applicability, including commercial. From an economic view, they are available from many suppliers and have a broad, competitive marketplace.

Table 5-5 shows this subsystem as top-ranked in the S&RE category with a raw score of 12/12. Standardization approaches are feasible for horizontal, vertical, and cooperative categories at the part and modular levels. Functional standardization is feasible at the module level, but the most desirable approach for this category seems to be a cooperative, logistical standardization at the part level. This technique would permit interservice, and international interoperability, a primary consideration in the AAAS Program.

5.2.6 Integration Equipment

A variety of S&RE elements are included under Integration Equipment, and can be divided into three types: carriage mode, power, and interconnection or transfer equipment.

Integration Equipment rates lowest among S&RE elements as a candidate for standardization. While the individual items of this subsystems are principally mature from a technological standpoint, their application is undergoing significant change, resulting in a rating of least attractive for

standardization at this time. The architectural rating for the equipment in this category is also regarded as least attractive since the carriage mode items are of complex design dictated by the emphasis on conformal carriage; the power sources involve evaluation of hydraulic and pneumatic concepts of greater complexity than present pyrotechnics; and the desire for common interconnection imposes tradeoffs involving many aircraft/stores electrical and fluid interchange requirements.

Applicability to multiple use was considered moderately attractive for standardization since different aircraft types are involved for most items and multiservice applications are being considered for some equipment. From an economic standpoint, since the items making up the equipment types are, for the most part, off-the-shelf types from many suppliers in a competitive marketplace, a rating of most attractive was applied.

These ratings provided this category of subsystem with a raw score of 7/12, the low end of the standardization ranking (see Table 5-5). Table 5-6 shows that most standardized approaches are feasible at the module level but not applicable at the subsystem level except for the vertical approach. Since the elements of this category are varied, Table 5-6 indicates that these three types of equipment be considered separately in identifying the most appropriate approach.

Section 6

AAAS ELEMENT STANDARDIZATION CHARACTERISTICS

This section presents the recommended characteristics for SMS and S&RE subsystems judged to be feasible candidates for standardization. Generally applicable characteristics are described first, followed by those pertinent to specific subsystems.

The functional, electrical, physical, and environmental aspects of the characteristics are described, and supporting rationale is provided for each, based upon qualitative technology assessments, potential cost impacts, intra-service commonalities, and interoperability requirements. Finally, alternatives to the recommended characteristics are presented, where applicable, for consideration by the AAAS Program Office.

6.1 SMS SUBSYSTEM STANDARDIZATION CHARACTERISTICS

Seven SMS subsystems were identified in Section 5.1 as being feasible for standardization. For those SMS subsystems most amenable to a functional (F³) standardization approach, the recommended characteristics are presented only at the subsystem interface level. For the SMS subsystems to which other standardization approaches would be more beneficial, the characteristics are described at the subsystem, module, and component levels.

The contract development specification, NWC Document 31803-80-80, establishes performance, design, development, and test requirements for an ADM SMS. That specification directs or suggests various standardization characteristics to be incorporated into the ADM SMS. Those characteristics and others were more precisely defined in this study through a review of current SMSs, associated industry standardization efforts, and avionics trends in industry and the DoD.

6.1.1 Characteristics Recommended for All SMS Subsystems

Various system-level standardization characteristics have been identified for application to all SMS subsystems to meet the objectives of the AAAS Program. These characteristics are presented in the general categories of Architecture, Packaging, Maintenance Philosophy, and Power.

6.1.1.1 SMS Architecture

The ADM SMS specification requires that the SMS shall be modular in design, allowing its adaption to any aircraft type regardless of the missions and stores assigned to the aircraft. The specification directs that two design approaches be explored: a wire-based system as the baseline, with a full fiber optic system or a hybrid system as alternative design approaches. The ADM SMS specification also incorporates the following standards that impact on the characteristics of a generic SMS architecture:

- . MIL-STD-454 Standard General Requirements for Electronic Equipment
- . MIL-STD-704 Aircraft Electric Power Characteristics
- . MIL-STD-965 Parts Control Program
- . MIL-STD-1378 Requirements for Employing Standard Electronic Modules
- . MIL-STD-1472 Human Engineering Design Criteria for Military Systems, Equipment, and Facilities
- . MIL-STD-1553 Aircraft Internal Time Division Command Response Multiplex Data Bus
- . MIL-STD-1679 Weapon System Software Development
- . MIL-STD-1760 Aircraft/Store Electrical Interconnection System

In addition to the above, two handbooks are invoked in the ADM SMS specification: MIL-HDBK-244, Guide to Aircraft/Stores Compatibility; and MIL-HDBK-255(AS), Criteria for Nuclear Weapon Systems Safety, Design and Evaluation.

The AAAS Program Office contracted for several independent studies that have identified and recommended various SMS architecture standardization characteristics. These projects included:

<u>Project Title</u>	<u>Contractor</u>
Advanced Weapon Signaling Requirements Study	Vought Corp.
Stores Management System Architecture Tradeoff Study	Booz-Allen, Inc.
Stores Management Systems Architecture Tradeoff Studies	Fairchild Space and Electronics Co.

The above studies suggest that the SMS architecture be characterized by a hierarchical structure employing distributed processing, with each module performing a set of closely related functions. The studies also recommend the following characteristics:

- . Modularity - Allocation of SMS functions into architectural components.

- . Autonomy - Each module should be capable of operating with a minimum of control from others. Separate buses are recommended for stores and Primary Station control.
- . Interface - The SMS should appear as a remote, intelligent terminal on a high-level multiplex bus (e.g., avionics bus), and the SMS should have its own lower-level data bus that connects all of the SMS-dedicated processing elements (C/DE and SSE). The SMS should also function as the controller for the SMS bus.

Therefore the following generic standardization architectural characteristics are recommended for all SMS subsystems:

- . Hierarchical structure with distributed processing
- . Digital designs
- . Interface functional elements with multiplex buses

6.1.1.2 Packaging

The ADM SMS specification requires that the SMS reflect a generic modular design and that the ADM hardware be capable of meeting the environmental requirements of MIL-E-5400, General Specifications for Aircraft Electronic Equipment, Class 1A. Further, the specification requires the use of a parts standardization program (MIL-STD-965) and use of standard electronic modules (MIL-STD-1378). No requirement is specified concerning the partitioning of each subsystem into LRUs, SRUs, and components.

The commercial airlines, and more recently DoD, have partitioned avionics systems into functional units to facilitate Operation and Support (O&S). Weight and size limits have been established to facilitate a remove/replace maintenance philosophy for aircraft subsystems. Recently the commercial airlines have established the modular concept unit (MCU) as the basic building block for avionic system design. The MCU has fixed height, length, and width as described in ARINC Specification 600-2. A line-replaceable unit (LRU) may consist of one or more MCUs, up to a maximum of 12 MCUs not weighing more than 20 kilograms.

As mentioned above, the ADM SMS specification requires the use of standard electronic modules (SEMs) in accordance with MIL-STD-1378. Incorporation of SEMs in the design of ground-base and shipboard electronic equipment has yielded favorable results. Not only have maintenance and logistics costs been reduced, but the reliability and availability of parts have improved. However, SEMs have not been used successfully to any great degree in avionics applications because of weight and volume penalties. The Air Force contracted with the Westinghouse Defense and Electronic Systems Center to determine the feasibility of an avionics SEM. The study concluded that there was no major technical obstacle to developing an avionics SEM, but no such program has been pursued to date. Therefore it appears questionable to require the use of SEMs in the design of SMS subsystems unless their current weight and volume restrictions are of no consequence.

The ADM SMS specification requires that ADM hardware meet the environmental requirements of MIL-E-5400, Class 1A. However, most ADM S&RE specifications require either Class 2 or 3. Unless other circumstances

dictate, both AAAS elements should be designed to the same environmental characteristics.

Based on the foregoing discussion, the following system standardization characteristics are recommended for all SMS subsystems:

- . Partition the SMS into standard-sized (height, length, and width) LRUs and SRUs.
- . Use design techniques that permit functional grouping of circuits.
- . Limit the weight of LRUs to a maximum of 55 pounds to facilitate their removal and replacement on the aircraft.
- . Partition LRUs into SRUs that can be readily removed and replaced at the shop serving the aircraft.
- . Use MIL-STD-1378 SEMs only in those instances where their high weight and volume will not constrain their application.
- . Direct that environmental requirements be per MIL-E-5400, Class 2.

6.1.1.3 Maintenance Philosophy

The ADM SMS specification does not specifically outline the maintenance philosophy to be implemented; however, several supportability objectives are stated. These include increased reliability and fault-isolation and diagnostic capabilities, improved maintainability, and reduced requirements for ground support equipment (GSE). Goals have been established for both reliability and maintainability. Finally, the specification provides for the incorporation of built-in test (BIT) for both failure detection and location. No mention is made in the specification that the SMS architecture be such that a compatible interface with automatic test equipment (ATE) be facilitated.

Current trends in the maintenance of digital avionics reflect the adoption of a two-level maintenance concept, with elimination of the need for the intermediate level shop. To implement this concept into general avionic equipment requires a departure from the present LRU concept. The new technique, as outlined in a paper by Westinghouse Electric Corporation, is to make the lowest replaceable assembly - a line-replaceable module, LRM - become the element removed from the aircraft. The LRM must be capable of withstanding rough handling and exposure to the elements associated with organizational level maintenance. The concept is dependent upon the employment of BIT for fault detection and isolation of the LRM. Until such a maintenance concept becomes standard practice, its implementation in the ADM SMS would introduce a nonstandard logistics requirement.

Based on the above considerations, the following standardization characteristics are recommended:

- . Adopt a three-level maintenance concept.
- . Establish a compatible interface for ATE using MIL-STD-2076, General Requirements for Unit Under Test Compatibility with Automatic Test Equipment.

- . Conduct BIT studies in accordance with MIL-STD-1591, Analysis/Synthesis of On-Aircraft, Fault Diagnosis, Subsystems, or equivalent BIT design guides.

6.1.1.4 Power

The ADM SMS specification invokes MIL-STD-704 and provides for power levels of 115 Vac, 400 Hz, 3 phase; 115 Vac, 400 Hz, single phase; or 28 Vdc. Such electric power requirements are common in most commercial and military aircraft systems.

The trend in aircraft electrical power systems is toward all-solid-state power conversion and power switching.

Future equipment may have switching power supplies that operate from either 115 Vac, 400 Hz, 3 phase, or 270 Vdc. The Navy's Advanced Aircraft Electrical System (AAES) is directed toward the development of an integrated electric power generation, power management, and data transmission system based upon a 270 Vdc generator. That voltage is converted to user levels by solid-state dc-to-dc and dc-to-ac regulated converters. The Air Force is also pursuing the application of solid-state switching and computer control of aircraft power systems. They are following but not supporting the use of high-voltage dc power.

Therefore the following standardization characteristics are recommended:

- . Use MIL-STD-704 electric power as specified.
- . Incorporate solid-state power conversion and switching.
- . Monitor the AAES Program for other opportunities to standardize design characteristics.

6.1.2 SMS Subsystem Standardization Characteristics

This section presents recommended physical and electrical characteristics that promote standardization of SMS subsystems within the AAAS Program. The functional characteristics were discussed in Section 2.1.2 and are delineated in NWC Specification 31803-80-80. The environmental characteristics were described in Section 6.1.1. Alternative characteristics, where applicable, are also presented for consideration by the AAAS Program Office.

6.1.2.1 Control and Display Equipment

As discussed in Section 5.1.1, standardization of Control and Display Equipment is best achieved utilizing the functional (F³) approach. Therefore it is essential to detail the characteristics of the C/DE subsystem interfaces.

In addition to the system-level military standards listed in Section 6.1.1, the following documents are recommended for applicability to standardized C/DE interfaces:

- . MIL-STD-783C Legends for Use in Aircrew Stations and on Airborne Equipment

- . MIL-STD-1553B Aircraft Internal Time Division Command/Response Multiplex Data Bus
- . MIL-C-17/45D Cable, Radio Frequency, Twin Conductor
- . MIL-C-38999 General Specification for Connectors
- . RS-170/EIA-343 Wideband Video (Transmit Television Raster Formatted Data)

The electrical characteristics of the C/DE interfaces should facilitate their accommodation on the avionics and/or SMS multiplex data bus(es). (Section 6.1.2.5 provides a discussion of the bus characteristics.) These C/DE interfaces can be readily standardized through application of standard RG-108 cable (MIL-C-17/45D), connectors (MIL-C-38999, Series III), and other appropriate industry signal format standards (RS-343-A for wideband video).

The physical characteristics of the C/DE interfaces should support the SMS system packaging and maintenance characteristics presented above. Each display should be a single LRU with replaceable modules (SRUs) packaged to group functionally related elements such as the CRT; keyboard, switches, and controls; input/output electronics; and power supply. All terms and abbreviations appearing on C/DE should adhere to MIL-STD-783C. Table 1 of that standard contains legends subject to international standardization agreements ASCC 10/16 and STANAG 3221. The following two documents should also be considered in standardization of the C/DE characteristics for the AAAS Program:

- . STANAG 3648AI Electronically and/or Optically Generated Aircraft Displays for Fixed Wing Aircraft
- . NATO Study 3845AA Display and Control Requirements Arising from the Management of Aircraft Stores, Internal Guns, and Dispensers

The above characteristics are recommended on the basis of the following rationale:

- . Technology - The technologies applicable to the design and development of C/DE are evolving and appears to offer the AAAS Program near-term opportunities to incorporate new features and capabilities. Standardization of the C/DE characteristics below the subsystem interface level would constrain the application of these new developments; however, functional standardization readily permits the incorporation of emerging technologies.

Both the Air Force and Navy are presently pursuing ADM programs for C/DE. These programs should be monitored for opportunities to standardize design characteristics.

The Air Force recently prepared a "Characteristic" for a standard INS control display unit (CDU). The Characteristic was written in the manner of an ARINC Characteristic, focusing on interfaces rather than on the internal detail design requirements. The approach used in the AF development of the CDU is the same as recommended for the AAAS C/DE.

- . Potential Cost Impacts - The employment of the above-recommended characteristics is expected to have minimal cost impact on the AAAS Program.

These characteristics can be easily realized by using standard DoD and/or commercially available parts.

. Intraservice Commonalities - The characteristics recommended would facilitate the use of the AAAS C/DE in most aircraft and would complement the Navy's logistics system. The legends of MIL-C-783C have been used in most recent aircraft, extensively for all cockpit C/DE in the F-18.

. Interoperability Requirements - NATO Study 3845AA states that C/DE standardization is not necessary for stores interoperability. However, the AAAS C/DE should possess the potential to control and display that information necessary for present and future stores. As a minimum, the legends used in the C/DE should be selected from Table 1 of MIL-STD-783C.

6.1.2.2 Process Control Equipment

Since it is feasible to standardize SMS Process Control Equipment using any or all of the standardization approaches but functional (see Section 5.1.2), the characteristics of the PCE should be addressed at all levels of standardization. This subsection describes the PCE characteristics required for achieving standardization at the subsystem, module, and component levels.

In addition to the system-level standards listed in Section 6.1.1, the following specific standards relating to standardization are recommended for PCE:

- | | |
|-------------------|--|
| . MIL-STD-1553B | Aircraft Internal Time Division
Command/Response Multiplex Data Bus |
| . MIL-STD-1679 | Weapon System Software Development |
| . MIL-STD-1750A | Sixteen-Bit Computer Instruction Set
Architecture |
| . MIL-T-85413(AS) | General Specification for Test Set, Computer
Memory Loader-Verifier AN/ASM-607(V) |

The electrical characteristics of the PCE subsystem interfaces should permit direct coupling to the SMS multiplex data bus (see Section 6.1.2.5) and communication with the host aircraft avionics bus via the Aircraft Interface Equipment (see Section 6.1.2.4). Intermodule communication should be via a uniform internal bus structure. Electrical components should be Mil-qualified and selected using MIL-STD-965. The PCE's design should utilize the Instruction Set Architecture (ISA) for a digital, microprogrammed airborne computer as defined in MIL-STD-1679. Definition of PCE-unique requirements, such as speed, should be based on the operational requirements for SMS. The ISA defines the characteristics of the PCE for:

- . Processor and input/output instruction sets (formats, operation codes, addressing modes)
- . Memory management and partitioning
- . Speed of accessible clocks
- . Interrupt structure
- . Manner of use and format of all registers and memory locations

The PCE's software characteristics are presented in Section 6.1.2.6. The PCE should be electrically and physically compatible with the Computer Memory Loader-Verifier AN/ASM-607(V).

The physical characteristics of the PCE should support the above interfaces and the system characteristics of all SMS subsystems (Section 6.1.1). The basic PCE should be constructed as a single LRU equivalent to an ARINC 8 MCU ("full ATR short") with the following recommended dimensions: 7.64"H x 10.09"W x 12.76"L. The PCE should be physically and functionally modularized into removable modules (SRUs), expandable by plug-in modules and additional enclosures, if required for other applications than the SMS. The physical dimensions of the modules should be standardized to facilitate interchangeability. Further, the modules should be standardized by function, with separate modules for memory, input/output, and others. Finally, the overall weight of the PCE should not exceed 44 pounds.

The above physical and electrical characteristics are based upon the following rationale:

- . Technology - Although the technology of minicomputers is constantly evolving, sufficient advancements have been made to permit standardization of the characteristics. If the recommended characteristics (e.g., standard functional modules) are implemented, new components resulting from various technology programs can be readily used to upgrade the PCE.

- . Potential Cost Impact - PCE meeting the characteristics identified above are currently being designed and developed. For example, Sperry-Univac's Reconfigurable Modular Family (RMF) includes the U-1824 and AN/AYK-15A products designed to those characteristics. These computers are expected to be somewhat less expensive than present airborne types.

- . Intraservice Commonalities - The AN/AYK-14(V) is the Navy's standard airborne computer and is GFE for Process Control Equipment for the ADM SMS. While the Army intends to use the computer in at least two programs, the Air Force has no plans for its utilization. The AN/AYK-14 was not based on MIL-STD-1750 but was designed to be compatible with the AN/UYK-20 Instruction Set Architecture. Of the many I/O modules available for the AN/AYK-14, only MIL-STD-1553A is available. Although the AN/AYK-14 does not reflect the characteristics of MIL-STD-1553B and -1750A, it does contain most of the other recommended characteristics.

Control Data Corporation, manufacturer of the AN/AYK-14 has developed the microcode for the AN/AYK-14 processor module to meet the requirements of MIL-STD-1750A. This module is currently undergoing test and validation, and is expected to be fully operational before the end of this year. Another module nearing completion is a 64K word memory to replace the two 32K modules presently used to achieve 64K words of memory. The new 64K module has the same dimensions as one 32K module. A 256K word memory module is also being developed that will be equivalent to the dimensions of two 32K modules. Another enhancement undergoing development is a MIL-STD-1553B interface module. Other product improvements are being considered, such as processing speed. With the incorporation of the above modules, the AN/AYK-14 will essentially satisfy the standardization characteristics recommended for the PCE.

. Interoperability Requirements - Adoption of the above enhancements for the AN/AYK-14 should make it essentially interchangeable with, and thus interoperable with, the Air Force's AN/AYK-15A. No specific STANAGs apply to the PCE's design characteristics. Associated STANAGs concerned with the SMS DTE (STANAG 3838AA and Study 3841A) and SMS software (Study 3839AA) are addressed in Sections 6.1.2.5 and 6.1.2.6, respectively.

6.1.2.3 Store Station Equipment

As previously discussed (Section 5.1.3), standardization of Store Station Equipment is best accomplished via the functional approach. This approach requires the detailing of SSE interface characteristics, leaving the internal design (module and component) characteristics to the developer.

In addition to the system-level characteristics discussed in Section 6.1.1, the SSE should also possess those subsystem interface electrical characteristics of C/DE and PCE already described. Included are those characteristics invoked by MIL-STD-1553B, MIL-C-17/45D, and MIL-C-38999 to standardize the SSE interface with the SMS multiplex data bus (see Section 6.1.2.5). The SSE's subsystem electrical interface characteristics with the SASI are defined in MIL-STD-1760, being jointly developed in an open forum under the A²I² Program. The intent of MIL-STD-1760 is to define the specific electrical characteristics and capabilities of power and data signals to be provided at the aircraft station-to-store interface, and provide a standardization guideline for final development of the logical and physical elements of the electrical interface.

The ADM SMS specification directs certain physical characteristics as design goals, including the requirements that the SSE not exceed 110 cubic inches and not weigh more than 12 pounds. In addition, it is recommended that the SSE be packaged into four modules representing the following functional areas:

- . Data bus and wiring interface
- . Process control
- . Signal conditioning
- . Power conditioning

The following rationale supports the selection of the above characteristics:

. Technology - As stated in the ADM SMS specification, the SSE is a critical item development for the AAAS Program. Although functionally similar equipment has been produced (e.g., encoders/decoders used on the F-18), the SSE requirements have never been fully implemented in equivalent operational equipment. Further, it is expected that the SSE will be generally more vulnerable to enemy threats, operate under severe environmental conditions, and be subject to extreme weight, volume, and heat dissipation restrictions. Finally, the miniaturization of the SSE is crucial. To satisfy these requirements, the SMS developer must be free of internal design restrictions and should be able to pursue various technologies. For these reasons the functional approach to standardization will

ensure standard subsystem interfaces while allowing the application of innovative technologies.

. Potential Cost Impacts - Implementation of the above standardization characteristics is expected to have a minimal effect upon the development cost of the SSE. All of the SSE subsystem interfaces, with the exception of MIL-STD-1760, can be readily produced with standard parts.

. Intraservice Commonalities - The recommended characteristics would facilitate the use of a functionally standardized SSE in new aircraft. The packaging of the SSE into functional, interchangeable modules would permit the SSE to accommodate emerging technologies and the signaling and control requirements of different S&RE and stores.

. Interoperability Requirements - In addition to the SASI requirements, the following two NATO documents should be considered:

- .. STANAG 3837AA Aircraft/Aircraft Store Functional Interface Connector
- .. Study 3840AA Automatic Store Identification

6.1.2.4 Aircraft Interface Equipment

The standardization of Aircraft Interface Equipment is best accomplished by the functional approach (see discussion, Section 5.1.4). As with the C/DE and SSE, this approach requires only standardization of the system interfaces, with internal design decisions left to the developer.

AIE have two electrical and physical interfaces, one with the avionics bus and a second with the PCE. The AIE input/output interface for the avionics bus should possess the same characteristics as for the other SMS subsystems that will operate on a data multiplex bus. These characteristics include those previously described in MIL-STD-1553B and MIL-C-38999. The AIE should operate as a remote terminal on the avionics bus.

The second subsystem interface, AIE to PCE, should be characterized as a hard-wire connection rather than a multiplex bus. The AIE will interface electrically and functionally with the PCE, and in turn the SMS with the aircraft's avionics bus.

The AIE should possess the physical characteristics of a single LRU with functionally packaged modules. Where possible, these modules should parallel those recommended for SSE.

The following rationale supports the selection of the above characteristics.

. Technology - Functionally similar equipment is being developed using proven technology and mature designs. For example, developers of GPS user equipment are currently designing a flexible modular interface (FMI) to interface the GPS set electrically and functionally with various host vehicles.

. Potential Cost Impacts - The effect on the development cost of the AIE to implement the above standardization characteristics is expected to be

minimal. All of the subsystem interfaces can be readily produced from standard components.

. Intraservice Commonalities - Depending upon the avionics bus structure utilized in the host vehicle, it may be necessary to accommodate an interface other than that characterized by MIL-STD-1553B. By using functionally packaged modules, it is possible to design other modules to accommodate different signaling and protocol requirements.

. Interoperability Requirements - The characteristics described above should facilitate the possible use of AAAS SMS elements in other service and NATO host vehicles. No NATO documents apply to AIE.

6.1.2.5 Data Transfer Equipment

The Data Transfer Equipment was found to be the most attractive SMS subsystem for standardization, and all standardization approaches except functional were considered feasible and achievable at all standardization levels. Characteristics of the PCE to achieve standardization at the subsystem, module, and component levels are addressed in this subsection.

In addition to the system-level standards, the following specific standards are recommended relative to standardized DTE interfaces:

- . MIL-STD-1553B Aircraft Internal Time Division Command/Response Multiplex Data Bus
- . MIL-C-17/45D Cable, Radio Frequency, Twin Conductor, RG-108A/U
- . MIL-C-38999 General Specification for Connectors
- . MIL-W-5088 Wiring, Aerospace Vehicle

Electrical characteristics of the DTE digital signaling requirements should reflect the requirements of a dual standby, redundant multiplex data bus as prescribed by MIL-STD-1553B. The bus should function asynchronously in a command/response mode, and transmission should be in a half-duplex manner. Control of information transmission on the SMS bus should reside in the PCE since the bus controller and PCE should initiate all transmission. Other aircraft buses (e.g., avionics or SSE) should be individually standardized depending upon the architecture of the host vehicle avionics and the architecture chosen for the SMS. The information flow on the data bus should consist of messages formed by three types of words (command, data, and status). The SSE and any SMS-dedicated C/DE should operate as remote terminals on the bus. The cable used for the bus should exhibit the electrical characteristics of MIL-C-17/45D (i.e., RG-108A/U). Electrical characteristics of the connectors should be as specified in MIL-C-38999, Series III. Electrical characteristics of wiring for DTE discrete signaling (audio, video, etc.) should be in accordance with those prescribed by MIL-W-5088.

Physical characteristics of DTE digital signaling should also be as prescribed by the above standards. The cable used for the SMS bus and all stubs should be a two-conductor, twisted, shielded, jacketed type such as described in MIL-C-17/45D for RG-108A/U. The cable should be coupled to the remote terminals with transformer-coupled stubs. The remote terminal's

interface with the bus should be packaged as a standard module. Wiring for other signaling should meet the physical characteristics of MIL-W-5088.

The following rationale supports the selection of the above characteristics.

. Technology - Wire-based MIL-STD-1553 digital multiplex buses have been installed in many recent aircraft. Traditionally, SMSs have been hard-wired between the store stations and cockpit controls. More recent SMSs have been computerized, but transmission to store stations has remained a hard-wire function. The successful standardization achieved in avionic buses using MIL-STD-1553 is indicative that the wire-based technology is sufficiently mature to apply to the SMS bus. Further, standard remote terminal transceiver modules have been developed and demonstrated (e.g., Circuit Technology, Inc. CT 3231 and Air Force standard 1553 modem chip set).

An alternative medium to the wire-based bus is fiber optics. The technology of fiber optics is rapidly evolving, but insufficient industry/government standardization has been generated to recommend that fiber optics be included in standardization efforts for DTE. The merits of fiber optics as a medium for multiplex buses have been demonstrated on the A-7. In 1973, a single high-speed multiplex fiber optic data link was designed, fabricated, demonstrated, and tested to interconnect the AN/ASN-91 airborne computer and the heads-up display (HUD) electronics unit. This program, the A-7 ALOFT (Avionic Light Optic Fiber Technology), utilized fiber optic communications technology available at the time, consisting of multimode fiber optic bundles, discrete semiconductor sources (LEDs), and detectors (silicon PIN diodes). More recently, the Air Force sponsored the development of a fiber optic transmitter/receiver unit (FOTRU) for use with MIL-STD-1553 data bus. The FOTRU is being created as part of the development of the AN/AYK-15A avionics processor.

Fiber optic standards are just beginning to be drafted and adopted by industry committees. A proposed military standard has been drafted by the Society of Automotive Engineers, A2K Committee Task Group on Fiber Optics, to define a "Fiber Optics Mechanization of an Aircraft Internal Time Division Command/Response Multiplex Data Bus System" compatible with MIL-STD-1553B. This same committee is also drafting a specification for a fiber optics transmit/receive unit. The Electronic Industry Association (EIA) is working on standards for five fibers. The EIA P6.6 Committee on Fiber Optic Standards has already standardized a long-distance optical fiber having a 50-micrometer core and 125-micrometer outer diameter. The DoD Standards Committee has approved standards for an optical fiber having a 100-micrometer core and 140-micrometer outer diameter. However, there can be no standards for fiber optics connectors until there are standards for the fibers to be connected. But even after the basic types of fiber are standardized in terms of core and outer diameter, it will probably be necessary to standardize other characteristics (e.g., concentricity, material, attenuation, etc.).

. Potential Cost Impacts - Implementation of a standardized wire-based multiplex bus would have minimal impact on the cost of DTE.

. Intraservice Commonalities - Recent signaling requirements analyses suggest that present and future requirements can be readily accommodated with MIL-STD-1553B bus or other hard-wired medium characteristics.

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. Interoperability Requirements - The characteristics described above should facilitate interoperability among the military services and NATO. Further, the following NATO documents should be considered in the design of the DTE:

- .. STANAG 3838AA Digital Time Division Command/Response
 Multiplex Data Bus
- .. NATO Study 3841A Safety Aspects Arising from the Application of
 Digital Data Bus Techniques to Stores
 Management

The Automotive Engineers A2K Committee Task Group on Fiber Optics and the EIA P6.6 Committee on Fiber Optics Standards should be monitored for standardization characteristic opportunities. Finally, the effect of Notice 1 (USAF), dated 12 February 1980, to MIL-STD-1553B, and the MIL-STD-1760 logical interface requirements being determined for the SSI, may have to be addressed to achieve the interoperability objectives of the AAAS Program.

6.1.2.6 SMS Software

The SMS software was found to be an excellent candidate for standardization, with standardization considered feasible at the subsystem and module interfaces. The following standards are recommended as best defining the software standardization characteristics:

- . MIL-STD-483 Configuration Management Practices for Systems, Equip-
 ment, Munitions and Computer Programs
- . MIL-STD-1679 Weapon System Software Development
- . MIL-S-52779 Software Quality Assurance Program Requirements
- . (Unknown) ADA High Order Language

The physical and logical characteristics of SMS software should reflect the standardization requirements of MIL-STD-1679, including as a minimum those imposed upon program design, languages, and intersystem and intrasystem interfaces. The SMS application programs should be written whenever possible in a high order language (HOL). Common SMS functions which can be standardized should be programmed in an intermediate language (e.g., pseudo-code, structured English) to facilitate their application. All programs should conform to the characteristics prescribed in MIL-STD-1679 for modularity, hierarchy, and size of routines. The interfaces between various elements of the SMS software should be well defined and the configuration strictly managed using MIL-STD-483 and -1679. The ATLAS HOL should be used for test applications.

The following rationale supports the selection of the above characteristics for the SMS software.

. Technology - Standardization characteristics for the design, development, documentation, and management of software have evolved over the past few years. More recently, those characteristics that promote standardization were promulgated in MIL-STD-1679. This document clearly delineates those characteristics that will best achieve standardization of the SMS software.

Several HOLs are on DoD's approved list. DoD Instruction 5000.31 Interim List of DoD Approved High Order Programming Languages", specifies the following six DoD standard HOLs be used:

FORTTRAN	COBOL
JOVIAL	SPL-1
CMS-2	TACPOL

An unpublished revision identifies the following HOL listing:

FORTTRAN	Ada
JOVIAL	ATLAS
CMS-2	

The Navy is using CMS-2M in avionic real-time applications (e.g., AN/AYK-14) and ATLAS for test applications. Further, software support tools for these languages have been developed and proven. Ada, which will be the new DoD standard, will not be fully available until the mid-1980's, and therefore CMS-2 is recommended as the HOL.

. Potential Cost Impacts - Implementation of the recommended characteristics for SMS software is expected to have minimal cost impact on software development. Application of the standardization characteristics of MIL-STD-1679, and use of an approved and supported HOL, should tend to lower the overall cost of the SMS software.

. Intraservice Commonalities - The adoption of MIL-STD-1769 and the use of CMS-2 in the development of software for the SMS would contribute to the standardization of software within the Navy's airborne processors.

. Interoperability Requirements - Application of the standardization characteristics prescribed by MIL-STD-1769 should facilitate interoperability among the military services and NATO. Eventual implementation of a standard HOL (Ada) in all services and by member nations of NATO will enhance interoperability and promote the standardization of SMSs. Finally, NATO Study Outline 3839AA, Design Measures Required to Achieve Flexible Organization of Software, should be considered in the design of SMS software.

6.1.2.7 Briefing Entry Device

The Briefing Entry Device (BED) was judged to be an attractive candidate for standardization, and all standardization approaches except functional are deemed to be achievable.

Only those standardization characteristics specifically defining the BED's interfaces with the aircraft exist as either government or industry standards. Therefore the characteristics prescribed by the following standards are recommended:

- . MIL-STD-1553B Aircraft Internal Time Division Command/Response Multiplex Data Bus

- . RS-232-C Interface Between Data Terminal Equipment and Data Communication Equipment Employing Serial Binary Data Interchange

In addition to the above, the BED should reflect the following characteristics:

- . Functional - The BED is a portable memory subsystem capable of initializing aircraft computers with specific operational data and of retrieving specific vehicle system operational and maintenance data. The BED should function as the medium to facilitate the preflight loading of data relative to flight path, navigation, weather, weapons, and other dynamic information requirements for a particular mission. The BED should also function as a postflight retrieval medium to facilitate the recovery of information relative to weapon data, BIT failures, navigational data, and other information key to the assessment of the mission.

- . Electrical - In addition to the subsystem interface characteristics prescribed above, the BED should possess sufficient memory capacity to satisfy its functional requirements, with the memory readily expandable within its physical limits. The BED should be powered with standard alkaline batteries.

- . Physical - The BED should comprise three principal elements; memory module, cockpit receptacle, and terminal. The memory module is a portable device with memory retention capability for the transfer of information to and from the aircraft. The cockpit receptacle would transfer the information to and from the memory module to appropriate aircraft systems (e.g., mission computer, SMS, PCE, etc.) via the avionics bus (MIL-STD-1553B multiplex bus). The terminal loads and processes the information for the memory modules. The terminal should consist of a CRT/keyboard for data entry and viewing, disc storage of data, a computer, software, and a hard-copy printer.

- . Environmental - Environmental characteristics of the BED should be the same as those prescribed in Section 6.1.1.2.

The following rationale supports the selection of the above characteristics:

- . Technology - Equipment functionally similar to the BED is available, utilizing current technology and proven designs. For example the Air Force recently sponsored the development of a functionally equivalent BED. This data transfer system, produced by Lear-Siegler, Inc., will simplify planning and automatic data insertion, retrieval, and storage. The system was deployed in 1979 on F-4Es and RF-4Cs and is currently being planned for the F-16.

The Naval Air Development Center is also sponsoring the development of a device similar to the BED as part of the ADM Advanced Integrated Display System (AIDS). This item, called a Briefing Information Entry Device (BIED), consists of a tape cartridge, tape cartridge drive unit, and an AIDS Digital Terminal (ADT) to perform many of the same functions as the Air Force's data transfer system, with the exception of the transfer of weapon data and the use of a MIL-STD-1553B interface. Further, the two programs are not physically compatible.

. Potential Cost Impacts - The effect on the development cost of the BED to implement the above standardization characteristics is expected to be minimal. All BED elements can be readily purchased or fabricated from standard components and commercial off-the-shelf products.

. Intraservice Commonalities - The interface characteristics (i.e., MIL-STD-1553B) would facilitate the use of a BED with the ADM SMS. The functional, physical, and electrical standardization characteristics would permit its application in various mission aircraft.

. Interoperability Requirements - Detailed functional, physical, and electrical standardization characteristics would have to be evolved to achieve any degree of joint service and NATO interoperability. The A²I² Program offers the appropriate open forum environment for the development of a BED standard.

6.2 S&RE SUBSYSTEM STANDARDIZATION CHARACTERISTICS

This section presents recommended standardization characteristics for S&RE, developed in the same general manner as for SMS (Section 6.1).

A series of Prime Item Development Specifications prepared by NWC establishes the significant performance, design, development and test requirements for the major ADM components of S&RE. These specifications are identified as NWC register numbers 31403-83-80, 31403-84-80, 31403-85-80 and 31403-86-80, addressing the 14" and 30" MUSE, Multiple Store Adapters, and Conformal Carriage System, respectively. Additional S&RE subsystem considerations are presented in a series of NWC technical descriptions, NWC position papers, industry/military-developed standardization criteria, trend information from current S&RE equipment developments, and NATO/DoD standard agreements (STANAGS).

6.2.1 S&RE Subsystem Common Characteristics

Specifications and other S&RE guidance documents for the ADM program emphasize S&RE modularity as an important design consideration for enhancing multi-aircraft, multi-mission, multi-stores application while minimizing complexity and logistic support requirements. Emphasis is also placed on the use of advanced technology and design innovation to bring S&RE to the current state-of-the-art of modern aircraft design. Applicable military standards, handbooks, specifications, and other general references identified in the development specifications are discussed in Section 6.1.1. The following sections describe the mechanical, electrical, and other characteristics that will facilitate S&RE standardization at appropriate levels in the AAAS ADM Program.

6.2.2 Primary Station

Section 5.2.1 offered the recommendation that functional standardization at the modular level be applied in Primary Station development. Definition of the modular levels utilizes the characteristics of the physical elements

comprising the Primary Station and the MUSE development specification. The Primary Station consists of:

- . 30" MUSE
 - Basic Structure (strongback)
 - Vertical Support, Engagement, and Latching
 - Swaybraces (triaxial restraint)
 - Store Release (primary)
 - Ejection System
 - Vertical Support Safety Interlock/Override
 - Electrical System
 - Jettison (secondary release)
 - Ejection Power System
 - Fuzing/Arming
- . Standard Store Electrical Interface
- . Fluids Interface
 - Fuel
 - Hydraulics
 - Pneumatics
 - Coolant
- . Bail Bar

Significant interface parameters for these elements were identified from review of the specifications and other documents, and discussions with S&RE personnel at NWC. During these discussions, standardization potential was assessed for most of the functional elements. This assessment was accomplished by qualitatively scoring most elements in a manner similar to that described in Section 5.1.

Reference documents providing the functional standards for interface between the aircraft and the Primary Station components, between the Primary Station components and the stores, and between the functional elements of the Primary Station are:

- . NWC-1006 Prime Item Development Specification for the AAAS 30-Inch MUSE (NWC-31403-83-80), undated preliminary copy
- . MIL-STD-2088 Bomb Rack Unit (BRU), Aircraft, General Criteria (draft, dated March 1980)
- . MIL-STD-1760 Aircraft/Store Electrical Interconnection System (dated 15 May 1981)
- . MIL-HDBK-244 Guide to Aircraft/Stores Compatibility (dated August 1975)

. MIL-A-8591

General Design Criteria for Airborne Stores,
Associated Suspension Lugs, and Aircraft/Store
Interface (dated January 1979)

AAAS Aircraft Hardpoint Technical Description
(NWC-31403-09-80) undated draft

From the standpoint of the Primary Station function, the aircraft hardpoint-to-station interface and the station-to-store interface require standardization to optimize the station utility. During the ADM development, metrication, attachment method, geometry, contact surface conditions between the aircraft skin and station components, and structural limits must be established. (Pylon and Special Station attachment similarities must also be considered.) The considerations should minimize requirements for special tools for installation or removal, and also minimize install-and-remove-time for any station components. The standard Aircraft/Store Interconnection defined in MIL-STD-1760 dictates the electrical parameters and their associated physical factors. Similar standard definitions are being prepared for the other interface considerations, based on the results of several efforts including a program being conducted by NADC. The complete interconnection standards are expected to specify the couplers for fuel, hydraulics, and pneumatics or coolant, defining their approximate positions relative to each other, the bail bar, and the MUSE.

6.2.2.1 30" MUSE

As a functional module of the Primary Station, the 30" MUSE requires a standard definition for envelope (6"W x 10"H x 50"L, max.); weight (65 lb. max.); and maximum stores load of 5,000 lb, as provided in the specification. The overall dimensions and total weight should consider shipboard handling by one man.

6.2.2.1.1 Basic Structure

The station-to-aircraft interface defines the attachment method geometry, and contact surface for this major functional module: the strongback or basic supporting structure for all other MUSE modules. The structure should provide for mounting all MUSE modules by using standard attachment techniques. It should satisfy the structural requirements for attachment consistent with minimum weight and adequate safety (ref. MIL-A-8591). To this end, innovative use of new materials (including composites) is encouraged in the specification.

6.2.2.1.2 Retention and Release Components

Four functions that are operationally interdependent in the attachment, support, and release of the stores, are considered here as a functional entity that could be modularized (except for hooks or other store suspension method) for use on either the 14" or 30" MUSE. These functions include:

- . Vertical support, engagement, and latching
- . Swaybraces
- . Stores release (primary)
- . Ejection system

Assemblies comprising several combinations of these functional categories have already been demonstrated.

The MUSE development specification defines the characteristics of these four functions. Maintenance and supply will be simplified through combining these functions and defining the module envelope, attachment method, geometry, contact surface, and method of connection with the release-power distribution system (whether mechanical or hydraulic). The ejection system should be programmable as to rate, end of stroke (EOS), and force levels on the store, preferably by the aircrew member from the cockpit. This requires definition of the method of control, and of the control and sensing signals between the SMS and S&RE.

6.2.2.1.3 Vertical Support Safety Interlock and Override

Although included with Vertical Support, this category is mentioned separately to emphasize its importance to the store loading/unloading safety of ground crew personnel. As described in the MUSE development specification, it should be included, as a separate in-flight operable bomb rack lock (IFOBRL).

6.2.2.1.4 Electrical System

The MUSE electrical requirements include actuation of the mechanical arming solenoids, electrical fuze arming through a release system linkage interlock, electrical control of the release and ejection power system, and BIT. Wiring can be standardized around MIL-W-5088 and MIL-E-5400. MIL-STD-704 aircraft electrical power will influence component selection but, to allow maximum latitude in determining the best technique for accomplishing arming and fuzing, release system power control, and BIT, standards for this element should be deferred until the Phase I effort is completed. Connectors should be standardized to MIL-C-38999 with pin requirements established early in Phase II.

6.2.2.1.5 Jettison (Secondary Release)

An important consideration for this item is the use of an independent release path to assure safe store separation from the aircraft in the event of a primary system failure. Differing degrees of path independence are possible. Selection of the specific method should be deferred until design alternatives become apparent after the ADM design evaluation.

6.2.2.1.6 Ejection Power System

Three ejection power techniques are under consideration for achieving cleaner, maintenance-free operation. Two of the three techniques, as now perceived, would require a source of energy on the aircraft. In this study, a pneumatic system was judged the least likely to be used and standardized (rated 8 of 12) since this application would be considered emerging technology. Hydraulics were also considered to be possible but unlikely (9/12). A dedicated system on all host aircraft would be considered necessary, adding undesirable complexity and weight to the aircraft. This would suggest that the pyrotechnic technique (11/12) would be retained for the ADM program at least for the present. Standards already exist for the pyrotechnic system elements (breech, caps, cartridges, etc.). These pyrotechnic elements should

be reviewed and updated to accommodate some of the new pyrotechnic techniques offering significant reduction in erosion and corrosion, and provide other maintenance-reducing, life-extending developments. Difference if any, in release/ejection power requirements for the 30" and 14" MUSE should be considered in terms of tradeoffs between unit cost, performance, weight, and life cycle cost.

To accommodate interchangeable modules between the 14" and 30" MUSE, which the specifications recommend, a separate power distribution system is indicated for each MUSE. This permits the use of MUSE-interchangeable power and release systems, with a distribution system peculiar to the individual MUSE strongback size. The principal standardizing requirements would be definition of the power module envelope, attachment technique and geometry, and the fittings or linkage to interface the power module and release module with the distribution system. Power distribution or ejector control, a possible technique to achieve store separation attitude control by the aircrew, should also be evaluated in Phase I to determine any restrictive impacts of standards.

6.2.2.1.7 Fuzing/Arming

Both mechanical and electrical arming techniques are possible, and some standards exist. The mechanical system consists of an arming wire (lanyard) loop, captivated by a standard solenoid-operated latch, which permits the mechanical fuze or retard fins on the weapon to be activated during weapon separation from the rack. The arming wire and clips can cause FOD hazard to nearby aircraft when the wires pull free during store separation. If modular alternatives are to be investigated during the ADM program, any added standardization should be deferred. Otherwise, the MIL-S-4040 arming unit solenoid can be retained as standard.

Electric fuzing will be accomplished through the standard store interface. Until this approach is implemented, the MK122 arming safety switch is the standard and its location defined by MIL-A-8591. Release linkage interlock will also be required.

6.2.2.2 SMS Interface

Electrical connections from the aircraft hardpoints to the armament system require a cable assembly. This assembly should be standardized to eliminate the need to carry multiple spare cable assemblies, connectors, or other parts for different aircraft combinations. A standard shear wafer, common to all stores, should be considered where umbilical disconnect is required during stores separation.

6.2.2.3 Fuel Interface

NADC is investigating the fuel interface, and any standardization considerations should be deferred until this investigation is concluded. Interconnection geometry standards should be considered at the S&RE/aircraft interface. Standard system components should be used in accordance with

MIL-F-8615 and MIL-C-7413. Components should meet requirements of MIL-F-8615 and MIL-C-7413.

6.2.2.4 Fluids Interface

Some stores require other types of fluid transfer between the aircraft and the store through a standard interface. Hydraulic fluid, pressurized air, coolant, or cryogenic liquid may be transferred. The interface must therefore provide for such interconnection. Location of the coupling(s) within the allocated interface surface is desirable to permit standardized umbilicals to be used. A standard umbilical would simplify logistic support. For hydraulic items, hoses and couplers that meet the environmental requirements should be selected per MIL-C-25427, MIL-H-8775, and MIL-H-5440. Pneumatics are governed by MIL-P-8564 and MIL-P-5518.

6.2.2.5 Bail Bar

During store separation from the aircraft, any electrical cable or fluid coupler assemblies providing connection to the store must be disconnected. Connectors designed to disconnect by a lanyard pull are used in many of these applications. The structural member at the aircraft hardpoint to which the lanyard is attached for connector release force is the bail bar. The bail bar should be standardized by designating its attachment method to the aircraft or S&RE element, and its diameter and length or maximum forces it must tolerate. These parameters should be established based on review of the past designs and projected requirements.

6.2.2.6 Rationale

The following rationale supports the standardization characteristics recommended for the Primary Station.

- . Technology - The Primary Station is a basic element in the ADM S&RE. A proliferation of station equipment has been developed in the past, in most cases to satisfy very narrow applications. In many of these devices, some limited capability of the AAAS Primary Station has been developed. However, each instance has failed to provide a combination of these capabilities to permit broad application. The functional approach to standardizing the Primary Station elements permits application of this developed technology in a versatile station. It also permits future technological advances to be incorporated by substituting more modern modules without requiring the redesign of the next higher assembly, and without internal design restrictions on each module.

- . Potential Cost Impacts - The standardization outlined above is not expected to impose any significant cost penalties on the design of the Primary Station. Many elements of the station are made of standard parts, readily available in the marketplace. The availability of standard items, and the simplifying effect it has on logistic support, suggest significant life-cycle cost savings. In addition, if future requirements are met using the standard station, the cost of unique station equipment development is eliminated.

- . Intraservice Commonalities - The standardization resulting from the recommended actions facilitates application to most aircraft, thereby

simplifying supply, training, and documentation requirements. It also encourages interservice interchangeability.

. Interoperability Requirements - A basic theme in the AAAS Program is the inclusion of NATO STANAG considerations in equipment design. An example is the influence of STANAG 3575AA in MUSE design requirements. This emphasis minimizes unique support requirements imposed by station elements in multi-service or international applications.

6.2.3 Missile Launcher (Rail Type)

Section 2.3.2 described three classes of missiles and their launchers. Class B and C missiles are designed for ejection separation from the aircraft. NWC intends in the ADM program to use the 30" MUSE as the ejector for these missiles. Since that device is discussed in Section 6.2.2.1, this section will address only the rail launcher.

For the rail launcher, the recommended standardization approach (functional) and level of standardization (subsystem) was developed in Section 5.2.2. Two documents have been prepared by NWC addressing the rail launcher standardization effort:

- . Position paper on STANAG 3842AA, Rail-Launched Missile Launcher Interface for Fixed Wing Aircraft, NWC 31803-70-79, June 1979
- . Position paper, Single-Use Rail Launcher vs Multi-Use Rail Launcher, NWC 31803-44-80, December 1979

These documents describe the variations in launcher design and review factors which must be reconciled to achieve a single rail launcher configuration.

For the subsystem approach to standardization, only the interfaces are defined, providing the designer with maximum flexibility. These interfaces are the rail-to-aircraft hardpoint and rail-to-missile.

The rail-to-aircraft hardpoint interface requires definition of the attachment method, geometry, and contact surface conditions. The contact surface has varied widely as a result of aircraft contour dictated by aerodynamic considerations. To achieve a single launcher configuration, a pylon or adapter may be required for those installations where aircraft design requirements result in contour or structural incompatibilities with the launcher contact surface. The adapter or pylon would be aircraft-peculiar, however, and should be discouraged. The launcher should attach directly to a bomb rack (MUSE), however, without an adapter and using either 14" or 30" attachment spacing.

In addition to the rail attachment requirement, the electrical interface must be standardized. This should follow the MIL-STD-1760 specification, but with a shear-wafer connection to terminate the electrical connections to the missile at launch. Similarly, to accommodate missiles requiring coolant or other fluid transfer (including launch boost if required), a self-sealing breakaway coupler would be needed (ref. MIL-H-5440 and MIL-C-25427). The position of these connections on the rail launcher must be defined.

The rail-to-missile mechanical interface also requires standardization. To accommodate the range of body diameters and fin configurations, the rail

arrangement must be given careful consideration. In addition, to assure no interference with adjacent aircraft structure or stores, the maximum envelope that can be used with the various missiles mounted must be defined. This is to protect against dual rail configurations that would significantly displace the missile position from that currently achieved by missile-peculiar rails. Location of restraint devices and surface contact area requires standardization to assure that missile hardpoints utilized by snubbers and detents, which stabilize the missile during captive flight, impose a minimum demand on missile surface area reinforcement and weight.

The following comments are offered to provide support for the selection of the stated characteristics:

- . Technology - Although no launcher has been produced that accommodates the total population of Class A and Class B missiles, currently available launchers are functionally similar and have proven designs. The AERO-5 launcher, as an example, can accommodate Shrike and HARM missiles (both Class B).

- . Potential Cost Impacts - A standard launcher design would eliminate the development costs of a new launcher for each new missile. In addition, spares, documentation, and training simplicity would significantly reduce logistic support costs.

- . Intraservice Commonalities - A standard rail launcher would provide greater assurance of operational readiness since all spares would be identical, permitting an aircraft that was recovered at a base other than its departure point to have a damaged unit replaced from a single universally stocked item.

- . Interoperability Requirements - The goal of international and interservice interoperability would be achievable, since standardization would permit interchangeability. Although interchangeability is not necessary for interoperability, it can provide a significant basis for that achievement of that objective.

6.2.4 Special Station

The Special Station is described in Section 2.3.3, and the assessment in Section 5.2.3 supports functional standardization at the modular level.

The Special Station closely approximates the Primary Station, with identical characteristics in many areas. The principal standardization documents involved are:

NWC-1007	Prime Item Development Specification for the AAAS 14" MUSE (NWC-31403-84-80), undated preliminary copy
MIL-STD-2088	Bomb Rack Unit (BRU), Aircraft, General Criteria (Draft), dated March 1980
MIL-STD-1760	Aircraft/Stores Electrical Interconnection System, dated 15 May 1981

MIL-HDBK-244 Guide to Aircraft/Stores Compatibility, dated
August 1975

MIL-A-8591 General Design Criteria for Airborne Stores, dated
January 1979

6.2.4.1 14" MUSE

The most significant difference between the two stations is the 14" MUSE, a unique part of the complement of the Special Station elements. The 14" MUSE, however, is very similar to the 30" MUSE, sharing some of the same modules but restricted to carriage of stores up to 1,000 pounds nominal weight. The principal differences between the 14" and 30" MUSE standardization considerations are discussed in the following paragraphs.

6.2.4.1.1 Strongback

The 30" MUSE strongback can be up to 50 inches long, while the 14" MUSE can only have 35" maximum length. The characterizing interface factors should be standard for all 14" MUSE. They include definition of the MUSE-to-aircraft attachment, which should be compatible with the attachment method, geometry, and contact surface with those characteristics of the 30" MUSE. The 14" MUSE strongback may accommodate the modules (power, release, and fuzing/armng) of the 30" MUSE if the results of AAAS ADM Phase I indicate that economic, weight, size, or other factors are acceptable. If the interchangeability of modules between the two MUSE is acceptable, the strongback would obviously require that the mounting attachment and structural standards be established. A maximum envelope must be specified for the 14" MUSE to facilitate its application with the Multiple Store Adapters to achieve a clean aerodynamic design.

6.2.4.1.2 Power System

The distribution of power from the power source module to the release/ejection module must be accomplished over less distance in the 14" MUSE, requiring different components. However, transfer of energy from the power source module to the release module, will require standardization within the 14" MUSE design. Compatibility with the two interface modules as well as attachment to the strongback will also require definition. The standards should consider interchangeable use of a hydraulic or mechanical power transfer device, to permit greater flexibility in accommodating future design improvements. A method of power distribution control, to permit aircrew control of store separation attitude, may also be considered, impacting the establishment of standards.

6.2.4.1.3 Vertical Support, Engagement, and Latching

The store support hooks or other attachment devices for the 14" MUSE require a rating of 1,000 pounds (nominal), and if appropriate must mate with the MS3314 lug. The 30" MUSE hooks, if used, require a rating of 5,000 pounds (nominal) and must mate with a NAVAIR Dwg. No. 1380540 Mk3 Mod 0 suspension lug or other appropriate device.

6.2.4.2 SMS Interface

Although primarily intended for application with the less sophisticated stores, the broad range of options associated with the Special Station, including the 30" MUSE, requires that the full MIL-STD-1760 interface capability of the Primary Station be used (see Section 6.2.2.2). This permits interchangeable umbilicals, and allows flexibility equivalent to the Primary Station in accommodation of future developments in stores or SMS technology.

6.2.4.3 Fuel Interface

The Special Station, when fitted with a 30" MUSE, does not necessarily include a fuel transfer capability. However, some aircraft (notably the AV-8 and A-10) cannot accommodate the mounting dimensions and loads associated with the 30" MUSE. Their stations, due to structural considerations, are restricted to the 14" MUSE, automatically confining them to the use of Special Stations. For some of their mission requirements, however, externally-carried fuel tanks are necessary. To satisfy these requirements, a fuel transfer capability must be included with the Special Station, and standards prepared for the fuel coupling, with designation of its location relative to other major Special Station elements.

6.2.4.4 Fluids Interface

The range of stores possible for accommodation by the Special Station dictates that standards for the Primary Station be applied (see Section 6.2.2.4). The rationale supporting the Primary Station standardization approach and levels applies essentially to the Special Station. Standardization at various levels (i.e., subsystem module) can provide equipment flexibility to accept technological advances without complete redesign. The benefits of interchangeability between aircraft are retained as well. Standardization can also reduce support costs and enhance reliability, maintainability, and most importantly, operational readiness.

6.2.5 Multiple Stores Adapters

For MSAs, functional standardization at the modular level was recommended (Section 5.2.4). Module performance characterization and standardization of the interface between modules is therefore required.

The principal reference documents providing standardization information are:

NWC-1008	Prime Item Development Specification for the AAAS MSA, NWC-31403-85-80, undated preliminary copy
MIL-STD-1760	Aircraft/Stores Electrical Interconnection System (dated 15 May 1981)
MIL-HDBK-224	Guide to Aircraft/Store Compatibility (dated August 1975)

MIL-A-8591

General Design Criteria for Airborne Stores, etc.
(dated January 1979)

Modular standards are addressed by considering general requirements concerning interface between the MSA and Primary Station, between the MSA and the stores, and between the principal elements (modules) of the MSA.

As described in Section 2.3.4, there are two MSA types: the dual store adapter (MSA-2) and the quadruple store adapter (MSA-4). The dual store adapter consists of the strongback and two 14" MUSE. The quadruple store adapter comprises a larger strongback and four 14" MUSE.

Considering the MSA-to-store interface, the MSA-2 is specified to have a capability of accepting two 1,000-lb (nominal) stores. The MSA-4 accepts four 1,000-lb stores. The MSA must provide electrical and fluids service to the stores, and sensing to establish stores status. Electrical connectors for the stores interface should conform to MIL-C-38999 Type III, and pin assignments designated. Any fluid requirements for present or future stores should dictate selection of couplers and/or umbilicals per MIL-H-8775, MIL-H-5440, and MIL-C-25427.

For the MSA-to-aircraft interface, the MSA-2 is to provide both 14-inch and 30-inch attachment devices. This will permit MSA-2 attachment to most aircraft, including those restricted to 14-inch suspensions (subject to their maximum station capabilities). The MSA-4 provides only 30-inch attachment devices for attachment to the Primary Station. The MSA electrical interfaces should be IAW the requirements of MIL-STD-1760. Specific requirements should include BIT, and are to be confirmed during AAAS ADM Phase I. MIL-STD-1760 requirements should be met by application of details determined after selection of station architecture. Fluid transfer requirements (hydraulic, pneumatic, or coolant), when established, will dictate component and assembly selections in accordance with the previously identified Mil-specifications.

Two strongback assemblies are required. The MSA-2 strongback provides for attachment of two 14" MUSE, using their standard hardpoint attachment method, pattern, and contact surface defined for the Special Station. The envelope volume to permit 14" MUSE installation must be specified. A multiplex arrangement for SMS signal distribution and stores control and interchange is required. The arrangement could be a quad port, interchangeable between the MSA-2 and MSA-4, with two ports terminated for MSA-2 applications. Previously mentioned Mil-specifications and standards apply. A distribution and control method (combination dual quad port manifold) for fluids should also be defined, but the specifics will be dictated by the MSA designers during Phase I, in accordance with the previously designated Mil standards. Both strongbacks must provide an aerodynamically efficient cover for the 14" MUSE to minimize drag at speeds up to Mach 1.4 (or 700 KCAS). According to NWC-1007, the maximum store diameter for the 14" MUSE is 20 inches. This would dictate a store spacing (14" MUSE lateral separation when attached to the MSA) of some dimension greater than 20 inches to allow for store diameter tolerance, MSA tolerance buildup, and clearance between stores to account for any deflections under load.

The rationale supporting the selection of the characteristics is presented in the following paragraphs.

. Technology - Recent developments in the Multiple Store Ejection Rack (MSER) program, supported by the Navy and Air Force, have demonstrated the feasibility of improving multiple store racks. The characteristics of the MSER and the BRU-33 (VER-2) dual rack, have influenced the performance expectations in the MSA development specifications. Phase I of the AAAS ADM Program will provide alternatives for additional improvement.

. Potential Cost Impacts - Standardization is expected to reduce costs by limiting the MSA development to a one-time expenditure, obtaining two standard items to be universally applied. Simplification of the inventory reduces support costs. In addition, if some of the more recently implemented procurement techniques are applied, competitive buys offer to reduce acquisition costs. They also provide incentives to achieve product improvement from technological advances at no extra cost to the government.

. Intraservice Commonality - One of the basic objectives of the AAAS ADM Program, stores to aircraft commonality, is strongly supported through standardization. Emphasis on standard modules and systems also reduces support requirements and provides assurance that a needed spare is available as a result of universal application.

. Interoperability Requirements - Standardization supports interoperability. It is necessary, however, to coordinate the standardization effort with the organizations with whom interoperability is to be achieved. Frequent exchanges (e.g., quarterly) with individual task assignments, and schedules to reconcile problems, would accelerate the effort.

6.2.6 Aircraft Hardpoints

This concept is discussed in Section 2.3.6. Standardization feasibility for this element of the SASI was rated 12 of a possible 12 (Section 5.2.5). The most desirable scheme was considered to be a cooperative logistical approach at the part level. This approach offers the best opportunity, through specific and detailed definition, to support the interoperability objective.

The AAAS aircraft hardpoint is the interface area between the airframe and pylon or between the pylon (as an extension of the aircraft airframe) and the S&RE. At the part level, for components applicable to the hardpoint, many specifications and standards exist. In addition, the following documents specifically relate to aircraft hardpoint standards:

	Technical Description of the AAAS Aircraft Hardpoint (NWC 31403-09-80), draft, dated 25 February 1981
MIL-A-8591	Airborne Stores, Associated Suspension Lugs, and Aircraft-Store Interface, General Criteria (dated 30 January 1979 and Amend. 1, dated 10 August 1979)
MIL-HDBK-244	Aircraft/Stores Compatibility Guide
MIL-STD-1760	Aircraft/Stores Electrical Interconnection System, dated 15 May 1981

The hardpoint consists of two main elements; the electrical and mechanical interfaces. The relationship of these interfaces to the pylon/airframe and S&RE to pylon or airframe is described in the following paragraphs.

6.2.6.1 Pylon-to-Airframe

NWC would prefer to develop a standard pylon. Variations in aircraft design, however, mitigate against such a goal. Aerodynamic shape differences and structure locations on different aircraft types (or in some cases even within type) pose individual mounting and fairing requirements for pylons. At this time, therefore, a standard pylon is considered unlikely. However, there are a number of variations in pylon attachment methods that should be evaluated for consideration as standard because of their ease of removal and replacement, reliability, cost, and other features. Another important feature is the attachment of the parent rack (MUSE), its location relative to the other interface components, and the accessibility of the stores after attachment.

6.2.6.2 S&RE-to-Pylon or-Airframe

The major suspension items that attach to the aircraft hardpoints are the 30" and 14" MUSE and the rail-type missile launchers. Airframe attachment points (hardpoints) are principally wing tips, pylons, wing surfaces, and the fuselage. The wing tips pose unique problems that may require a pylon or adapter to permit attachment, unless the aircraft designer makes a specific commitment to offer a direct rail attachment. Pylons, some underwing surfaces, and some fuselage stations have mounting surfaces suitable for direct MUSE or rail attachment. A standard set of components in a defined location can eliminate some of the pylon/adapter requirements. Sections 6.2.2.1, 6.2.3 and 6.2.4 address the standardization of the MUSE and rails. Their mounting geometry, method, type of attachment, and contact surface characteristics are to be standardized. The aircraft hardpoint must be compatible.

At the hardpoint area, a suitable structure is designed to accommodate the intended loads. Fasteners must be specified for S&RE attachment (including consideration of metrication). For jettisonable parent racks, explosive bolts may be a viable option. The fasteners should be selected from AN, AND, MS, NAS, NA, or DS standards, suitable for the loads expected. The number and location of the attachment devices should permit attachment of both MUSE and the rail launcher. The standard hardpoint should identify a position or boundary for a standard bail bar and each connector or coupling for fuel, hydraulic, or coolant; and identify a type that will provide acceptable operation through the range of conditions of environment and transfer fluid characteristics. Military specifications regarding these considerations were identified earlier.

MIL-STD-1760 addresses the aircraft/stores electrical interconnection. Additional signal or power requirements must be considered for such items as pylon lights and fuel pumps (for fuel transfer between the aircraft and an external tank).

The rationale for the standardization discussed is presented in the following paragraphs.

. Technology - Meeting the requirement of standardization demands the dedication and commitment of designers and managers of aircraft and stores. Many of the required components are available commercially under Mil-specification or other standard designations.

. Potential Cost Impacts - Standardizing the hardpoints, particularly on new designs, should impose no additional cost burden on the designer - merely a commitment to its accomplishment. The result should be a substantial reduction in the support costs based on fewer but universally applicable spares.

. Intraservice Commonality - This factor is a direct benefit of standardization. Universal spares, reduced documentation, decreased training requirements for higher level of maintenance proficiency, and less special test equipment or tools, all stem from standardization.

. Interoperability Requirements - NATO requirements as documented in the STANAGS, if addressed and coordinated during design, can be adequately addressed through standardization. Ease of support is a key benefit.

6.2.7 Integration Equipment

The key elements forming this category are carriage components and unique items such as alternative power sources and cable or hose assemblies (umbilicals). They are described in Section 2.3.5 and evaluated relative to standardization in Section 5.2.6. Their rating placed them at the bottom of the ranking as current standardization candidates.

In addition to the standardization documents covered in the universal application, the following have particular significance in this section:

NWC-1016	Prime Item Development Specification for the AAAS Conformal Carriage System (CCS), (NWC-31403-86-80), undated preliminary copy
_____	NWC, Technical Description of the AAAS Pylons, draft document, dated 25 February 1980
MIL-HDBK-244	Aircraft Stores Compatibility Guide (dated August 1975)
MIL-STD-1760	Aircraft/Stores Electrical Interconnection System (dated 15 May 1981)

The three elements in this category differ significantly in their adaptability to standardization. Consequently, each will be treated separately in the following sections.

6.2.7.1 Carriage Components

6.2.7.1.1 Conformal Carriage

For the AAAS ADM Program, only the Conformal Carriage System and pylons are under consideration. The conformal carriage will be unique to the F-14 application and it is premature to determine the extent of the application of

the results to standardization for the balance of the F-14 population or for other aircraft. Based on the Navy's previous experience with the F-14, considerably limited access to individual stores loaded on the aircraft made store status determination difficult. It also inhibited replacement of an embedded store or suspension item that was suspected of a defect. Use of preloaded trays could reduce the access problem by offloading the tray for status check or single store replacement. Careful positioning of any tray or stores on the tray would be necessary to assure seeker or tracker acquisition-window effectiveness for missiles contained in the tray. MSA use is precluded. Any standardization decisions should be deferred until at least partial Phase II results are obtained.

6.2.7.1.2 Pylon

The pylon is presently a major hardpoint for the Navy's attack aircraft stores carriage. Its main disadvantages are its greater radar cross-section and less-than-aerodynamically-clean characteristics. These shortcomings are associated with benefits of the pylon's open accessibility and versatility. A new design application may reduce RCS and drag, but it is to be for experimental use on the F-14. Standards for this application, therefore, should be deferred until Phase II inputs are at hand.

6.2.7.2 Power Sources

This subject was discussed in connection with the 14" and 30" MUSE. Both pneumatic and hydraulic approaches were considered to involve too much risk for this phase of the effort. Pyrotechnics are expected to be used. Standardization of pyrotechnics has already occurred, but new, cleaner, and more reliable devices are becoming available. New standards should be developed around these new devices as the performance proof data become available.

6.2.7.3 Transfer Items

These connectors, cables, couplings, and hoses, and their assembly into umbilicals, offer promise in minimizing the time needed for preparation, loading, and unloading stores. The components are all available as standard items according to existing aerospace specifications. Their application in the F-14 should be appraised during Phase I and carefully evaluated as to their benefits and weaknesses.

At this point, standardization of the items in the Integration Equipment category should be deferred. The items are principally unique to the F-14 in this program, and should be used to provide information to definitize requirements that can be more widely utilized.

6.3 IMPLEMENTATION OF AAAS PROGRAM STANDARDIZATION

Implementation of an AAAS standardization program necessitates that several activities be performed. These activities include:

- . Assessment of ADM contractors for standardization plans
- . AAAS Program ADM interface control

- . Definition of the Standard Armament System Interface (SASI)
- . Assessment of AAAS Program standardization characteristics on mission aircraft
- . Development of an AAAS Program standardization cost model

The above activities are discussed in the following paragraphs.

6.3.1 Assessment of ADM Contractors for Standardization

Using the standardization candidates and characteristics developed in this report, the NWC AAAS Program Office should critically assess the prospective ADM contractors for their proposed conduct of a standardization program. The first step in this assessment is to evaluate and rank each offerer's Phase I proposal concerning his approach to meeting the standardization objectives outlined in this report. Further, during the conduct of Phase I, each contractor's progress should be monitored and measured through review of his contractual deliverables and presentations during technical review meetings. Finally, the above assessment should culminate in the preparation of Phase II proposal evaluation criteria that result in the selection of an ADM contractor approach that best satisfies the standardization objectives of the AAAS Program.

6.3.2 AAAS Program ADM Interface Control

During Phases I and II of the AAAS Program, different contractors will be defining, designing, and independently developing ADMs of SMS and S&RE subsystems. A key task of the AAAS Program Office during this effort will be to ensure that the ADMs, once developed, properly interface with one another. This activity is best controlled through the evolutionary development of an Interface Control Document (ICD).

To organize and support the development of an ICD, the AAAS Program Office should establish an Interface Control Working Group (ICWG). Initially a charter should be prepared for the ICWG that describes the roles and responsibilities of all members and participants. Further, the ICWG charter should prescribe those procedures to be used to formulate and evolve the ICD.

Once the ICWG has been properly organized, a "strawman" ICD should be prepared based upon all AAAS contractor and program office inputs that address the following:

- . Scope
- . Applicable documents
- . Requirements, to include system definition, system characteristics, standard interfaces, standard connectors, etc.
- . Provisions
 - . Preparation for delivery and notes, as required.

Procedures should also be prepared that address in detail the use of tools, commands, etc. Multiplex data bus connections are best illustrated through the use of bubble

diagrams. These diagrams should illustrate the name, direction, origin, and destination of each message. Tables should be prepared that reflect for each multiplex bus terminal its source data block, destination, data words, and type of data transfer.

The "strawman" ICD should be distributed among the SMS and S&RE contractors and their inputs coordinated and incorporated into an updated version of the ICD. The ICD should be iterated among all concerned parties until all interface issues are resolved and documented. The ICD would then become a controlling document for the duration of the ADM Program.

6.3.3 Definition of SASI

Efforts should continue to evolve the Standard Armament System Interface under the sponsorship of the A²I² Program. Both parts of the SASI, the Standard Aircraft Interface and the Standard Store Interface, should be defined in an open forum environment to achieve interservice interoperability. Care should be taken to ensure that the final configuration of the electrical and mechanical portions of the SASI are compatible with the SMS and S&RE being developed under the AAAS Program.

6.3.4 Impact on Mission Aircraft

An assessment should be made to determine the impact of applying the standardization characteristics recommended in this report on those aircraft designated in the AAAS mission requirements document. The assessment should address the requirements of each aircraft to achieve intersystem standardization. Further, a timely, phased strategy should be developed to implement the identified requirements.

6.3.5 Development of AAAS Standardization Cost Model

A model should be developed to assess, quantitatively, the cost effectiveness of standardizing the AAAS SMS and S&RE subsystems. The model should be capable of estimating the cost of implementing each of the characteristics identified in this report. From that cost input, the model should then estimate the cost-effectiveness of the standardization characteristics when compared with the non-standardized elements. The cost model should include the cost categories of research and development, installation, support equipment, training, and technical documentation.

Section 7

CONCLUSIONS AND RECOMMENDATIONS

7.1 CONCLUSIONS

Information obtained and evaluated as part of this contract effort has indicated that very little standardization has been realized in the development of aircraft weapon control systems, including the Stores Management System (SMS) and particularly the Suspension and Release Equipment (S&RE). Rather, special armament-system design features unique to aircraft or particular weapon systems are used as expedients to obtain the desired, immediate system results. Consequently, a proliferation of highly specialized SMS and S&RE has accrued in the Navy inventory.

Supporting this spectrum of equipment has become a serious logistics problem. Configuration management is complex, at best. Small quantities of specialized spares must be purchased at premium prices to support each unique group of equipment, resulting in a complex and costly logistics program. Maintaining adequate spares aboard ship during deployment is also difficult. Assuring adequate skills on the part of maintenance personnel is a formidable task because of the wide range of special items that must be understood to maintain personnel proficiency. A profusion of documentation must also be maintained to support this equipment. Reconfiguration of aircraft to support varied missions is complex and time consuming, limiting operational readiness. Aircraft recovered at alternates to their launch sites may not find unique support spares available. In addition, interservice and international cooperative operations cannot be effectively supported due to peculiar stores carriage and control factors.

This situation has placed strong emphasis on standardization considerations in the AAAS ADM Program. Particular attention is focused on establishing a very limited variety of SMS and S&RE subsystems with broad application and utility for all Navy aircraft, weapon systems, and stores, with consideration for interservice and NATO interoperability.

It is concluded from this study, that standardization is not only possible at many levels within the SMS and S&RE subsystems, but in most cases can be highly beneficial to overall Navy operations. Acquisition as well as support costs can be significantly reduced. Standardization can be achieved at the subsystem, module, or component (part) level, depending on the characteristics of particular SMS and S&RE elements, and frequently can be applied for multi-aircraft, multi-mission operation and support benefit.

7.2 RECOMMENDATIONS

Specific near-term standardization efforts are recommended in the individual sections of the report addressing SMS and S&RE subsystems.

To implement the standardization program, several steps are necessary. First, the AAAS Program Office should critically evaluate each Phase I proposal offeror's approach and commitment to the AAAS Program objectives. Each offeror should be ranked accordingly, and the Phase I contractor selection strongly influenced by this ranking. Further, during the first phase, each contractor's performance against his proposed standardization tasks and milestones should be critically assessed and used as the basis for selection of the Phase II ADM contractor most strongly committed to the standardization objectives of the AAAS Program.

The AAAS Program Office should develop and require adherence to an Interface Control Document (ICD). The ICD should be used in conjunction with an Interface Control Working Group (ICWG) as the chartered basis for assuring achievement of program goals. This procedure is implemented through effective structured interaction between all ADM Program participants, both government and contractor.

Continued AAAS Project Office support of and participation in the A²I² Standard Armament System Interface (SASI) open forum should emphasize achievement of a final, compatible standard electrical and mechanical SASI interface between SMS and S&RE.

An assessment of the consequences that armament system standardization may have on aircraft identified in the AAAS mission requirements document should be undertaken. This must be done to assure timely consideration of the application of the standardization alternatives to mission aircraft.

The cost impact of the standardization characteristics identified in this report should be quantified and assessed. Such an assessment requires the discipline of a suitable cost model that provides a comprehensive basis for quantification. Such a model would readily permit cost-effectiveness comparisons between standardized and unstandardized approaches.

Careful consideration of a wide range of factors is needed to optimize future SMS and S&RE system standardization without restricting the potential for assimilating technological improvements, to improve interservice and international interoperability, and to achieve the capability of upgrading and standardizing currently operational systems. Such an effort, as has been demonstrated in some Navy programs, in the airline industry, and in Air Force efforts, can be most effectively carried out through frequent (e.g., quarterly) open-forum meetings such as those sponsored by the JTCG Weapons Panel.

To facilitate the development of standards and, more importantly, of equipment to meet the standards in a timely fashion, personal or organizational action items should be assigned during these open forum meetings. The action items should specify completion dates, with each open-forum meeting serving as a highly structured period for information exchange, task

coordination, and presentations on task completion. This process should involve industry as well as government, on an international basis, to assure that assigned tasks are broadly approached to develop specific resolution, and are executed in a well coordinated fashion.

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APPENDIX B

GLOSSARY

<u>Term</u>	<u>Definition</u>
AAAS	Advanced Aircraft Armament System
AAES	Advanced Aircraft Electrical System
A ² I ²	Aircraft Armament Interoperable Interface
ACSD	ADM Contractor Stores Data
ADM	Advanced Development Model
ADT	AIDS Digital Terminal
AIDS	Advanced Integrated Display System
AIE	Aircraft Interface Equipment
ALOFT	Avionic Light Optic Fiber Technology
AMAC	Aircraft monitor and control
ARINC	Aeronautical Radio, Incorporated
ASIDS	Aircraft/Stores Interface Data System
ASIM	Aircraft Stores Interface Manual
ATE	Automatic test equipment
ATR	Air Transport Rack
BED	Briefing Entry Device
BER	Bomb Ejector Rack
BIED	Briefing Information Entry Device
BIT	Built-in test
BITE	Built-in test equipment
BRU	Bomb Rack Unit
CCS	Conformal Carriage System
CDU	Control and display unit
C/DE	Control and Display Equipment
CILOP	Conversion in Lieu of Procurement

<u>Term</u>	<u>Definition</u>
CRT	Cathode ray tube
DAIS	Digital Avionics Information System
DITS	Digital Information Transfer Standard
DoD	Department of Defense
DTE	Data Transfer Equipment
DTS	Data Transfer System
EIA	Electronic Industries Association
EOS	End of stroke
ERU	Ejector Rack Unit
EW	Electronic warfare
F3	Form, fit, and function
FMI	Flexible modular interface
FOSIS	Fiber Optics Storage Information System
FOTRU	Fiber Optic Transmitter/Receiver Unit
GBU	Guided Bomb Unit
GFE	Government furnished equipment
GSE	Ground support equipment
HOL	High order language
HUD	Heads-up display
ICD	Interface control document
ICWG	Interface Control Working Group
IFOBRL	In-flight operable bomb rack lock
INS	Inertial navigation system
ISA	Instruction Set Architecture
JTCG	Joint Technical Coordinating Group
LED	Light emitting diode
LRM	Line replaceable module
LRU	Line replaceable unit
LSI	Large-scale integration
MCU	Modular concept unit
MER	Multiple ejector rack
MIRA	Multifunctional Inertial Reference Assembly
MSA	Multiple Stores Adapter
MSER	Multiple Stores Ejector Rack
MUSE	Modular Unit Suspension Equipment

<u>Term</u>	<u>Definition</u>
MUX	Multiplex
NADC	Naval Air Development Center
NATO	North Atlantic Treaty Organization
NWC	Naval Weapons Center
PCE	Process Control Equipment
PFA	Participating Field Activity
RCS	Radar cross-section
RMF	Reconfigurable Modular Family
RT	Remote terminal
SAI	Standard Aircraft Interface
SASI	Standard Armament System Interface
SEM	Standard electronic module
SLEP	Service Life Extension Program
SMS	Stores Management System
SRU	Shop replaceable unit
S&RE	Suspension and Release Equipment
SSE	Store Station Equipment
SSI	Standard Store Interface
STANAG	Standardization Agreement
SW	Software
TER	Triple ejector rack
TIM	Technical Interchange Meeting
VER	Vertical ejector rack
VLSI	Very-large-scale integration
WBS	Work breakdown structure
WIDS	Weapon Interface Data Summary
WRA	Weapon replaceable assembly